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Analysing the Allocation of International Adaptation Funding in Relation to the Societal Impacts of Climate-Related Hazards

GEO 511 Master's Thesis

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Abstract

Climate change is altering the intensity and frequency of climate-related hazards, which, combined with rising vulnerability and exposure of people to such hazards, is leading to increased disaster risk. This particularly threatens the populations of developing countries, especially those living in mountainous regions. In this context, climate change adaptation is an approach with great potential to save lives and to ensure sustainable development. However, uncertainties remain about whether current adaptation measures are effectively addressing the most serious disaster risks. This Master's thesis explored this issue globally for developing countries and specifically for High Mountain Asia countries. The study compared fatalities caused by four types of hazards (i.e. riverine floods, landslides, glacial lake outburst floods, and snow avalanches) with the amount of adaptation funding from two international climate funds of the UNFCCC finance mechanism (i.e. the Green Climate Fund and the Adaptation Fund). The analysis revealed that the deadliest hazards do not necessarily receive the most funding. In particular, snow avalanches are relatively underfunded, while GLOFs receive substantial funding despite causing fewer fatalities than other hazards. This imbalance reflects that many other factors influence the distribution of adaptation funding, such as political considerations or hazard perceptions. It further indicates the need for a more detailed analysis of the allocation of financial resources from other components of both the UNFCCC and non-UNFCCC finance mechanisms. This would provide a more comprehensive picture of funding distribution, supporting the development of strategies to enable an efficient allocation of adaptation funding.

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Abbreviations

AF	Adaptation Fund
CCA	Climate change adaptation
COP	Conference of the Parties
DRR	Disaster risk reduction
EM-DAT	Emergency Events Database
GCF	Green Climate Fund
GHGs	Greenhouse gases
GLOF	Glacial lake outburst flood
HMA	High Mountain Asia
IPCC	Intergovernmental Panel on Climate Change
IPCC AR6	Intergovernmental Panel on Climate Change 6^{th} Assessment Report
SDG	Sustainable Development Goal
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

1.1. Context

Each year, millions of people around the world suffer from the severe consequences of natural disasters (Cvetkovic & Dragicevic, 2014), which are defined as disastrous events that occur when natural hazards (e.g. floods, landslides, etc.) impact "(…) an exposed, vulnerable and ill-prepared population or community (…)" (UNDRR, 2008, p. 5). Over the past few years, there were several major natural disasters in various parts of the world (Onyango & Uwase, 2017). Examples include the earthquakes in Haiti (2010), Türkiye (2023), and Afghanistan (2023), floods in Pakistan (2010), hurricanes in the United States of America (2005) and the Caribbean (2017), bushfires in Australia (2019-20), landslides in Papua New Guinea (2012 and 2024), or glacial lake outburst floods (GLOFs) in India (2013 and 2023). The consequences of catastrophes such as these are devastating and far-reaching (Onyango & Uwase, 2017), as they may result in significant loss of life, injuries, and community displacement. Furthermore, they can cause major damage to (critical) infrastructure, negatively impact social systems, and even disrupt economic activities leading to loss of livelihoods and poverty (Botzen et al., 2019; Cvetkovic & Dragicevic, 2014; ESCAP, 2018). Additionally, natural disasters damage ecosystems, resulting in biodiversity loss and degradation of natural resources (Israel & Briones, 2012). Because of these multiple impacts, natural disasters can be considered as a serious threat not only to human well-being, but also to sustainable development in the broader sense (Sha Alam Khan, 2008).

Alarmingly, scientists argue that the risk of natural disasters is likely to increase in the future, resulting in more severe impacts and consequences (Coronese et al., 2019). In this context, climate change plays an important role (Wahlström, 2009). Natural hazards, especially those which are related to climate, are likely to become more intense and more frequent (Kohler et al., 2010) and the vulnerability of communities to such hazards is predicted to increase, as climate change also impacts on livelihoods, food security, and community health (Tschumi & Zscheischler, 2020). Considering the increasing exposure of infrastructure and people to natural hazards as a result of expanding tourism, growing population and socioeconomic development (Hock et al., 2019b), these factors cause an increase in disaster risk, which poses major challenges to humankind (Wahlström, 2009).

To enable better coping with such risks, climate adaptation plays a crucial role. In this respect, the term "adaptation" describes induced changes which should allow a better response to altered climate conditions. Thus, the main objective of climate adaptation is to reduce long-term risks, which are related to climate change (specifically designated as climate change adaptation (CCA)) and climate variability (City of Baltimore Commission, 2013), in order to save lives and protect livelihoods (UNFCCC, 2022). This is to be achieved through the implementation of a wide range of measures in the form of adaptation projects and strategies (UNDRR, 2008) targeting different sectors, including disaster risk reduction (DRR) (Caravani, 2015). The basis for funding such adaptation efforts is given by the climate finance mechanism, which involves "(…) local, national or transnational financing - drawn from public, private and alternative sources of financing (…)" (UNFCCC, n.d.-e). The main purpose of this mechanism is to provide recipients, that are highly vulnerable to the impacts of climate change, with the financial resources they need to achieve their specific adaptation goals (Watson et al., 2024).

1.2. Relevance

The people most susceptible to the increased disaster risk associated with climate-related hazards are those living in developing countries. They are particularly vulnerable to the impacts of climate change and natural disasters due to poverty and socioeconomic disadvantages, resulting in limited capacity to cope with disaster risks. As a result, people living in developing countries are disproportionally affected by natural disasters (ESCAP, 2018). This is reflected in the particular high number of fatalities recorded in these countries (Tschumi & Zscheischler, 2020).

From a more specific perspective, mountain regions, similar to developing countries in general, are also significantly affected by the impacts of climate change and natural disasters (Stäubli et al., 2018). Mountain regions cover around 24% of the world's land surface (Ariza et al., 2013) and are home to approximately one fifth of the world's population (Stäubli et al., 2018). Globally, they play a central role, as they provide fundamental services and goods, such as fresh water reserves, raw materials, and cultural and biological diversity (Ariza et al., 2013). Thus, mountain regions can be considered as crucial regions in the context of sustainable development (Stäubli et al., 2018). However, these regions are generally prone to natural disasters due to the topographical characteristics of the landscape, leading to a high exposure to various hazards (Schneiderbauer et al., 2022). Furthermore, the aforementioned (cultural) ecosystem services, as well as mountain communities themselves, are highly vulnerable to the effects of climate change and natural disasters (Schneiderbauer et al., 2021; UNDRR, 2002). Thus, in addition to the fact that 90% of the world's mountain population live in developing countries (Aggarwal et al., 2021), these people often face specific vulnerabilities, usually associated with their remoteness from centres of power and important services, limiting their capacity to deal with disaster impacts (Schneiderbauer et al., 2022).

Against this background, there is a clear need for CCA and therefore climate finance to address the increasing risk from climate-related disasters in developing countries and specifically in mountain regions in order to provide human safety, protect livelihoods, and preserve crucial ecosystem services in view of sustainable development. This contributes to the achievement of Sustainable Development Goal (SDG) No. 13, namely to "take urgent action to combat climate change and its impacts" (UN, n.d.-a), Target 13.1 of which is to "strengthen resilience and adaptive capacity to climate-related disasters in all countries" (UN, n.d.-a).

1.3. Motivation and Research Gap

As mentioned above, the core purpose of CCA is to save lives threatened by the impacts of climate-related risks (UNFCCC, 2022), which ultimately contributes to sustainable development. In order to effectively achieve this goal, it is essential that adaptation efforts are focused on mitigating the climate-related hazards that have the greatest societal impacts (i.e. that cause the highest losses). However, according to the cross-chapter paper on mountains published in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), "(…) there is limited evidence on the (…) long-term effectiveness of these [adaptation] measures addressing climate-related impacts and associated losses (…)" (Schneiderbauer et al., 2022, p. 2276). Thus, there is uncertainty as to whether CCA measures are optimally reducing climate-related risks in mountain regions. However, it is important to provide clarity on this issue as effective adaptation measures are the basic prerequisite for CCA to serve its full purpose. Since climate change poses a global issue, particularly affecting developing countries in general, not only those encompassing mountainous areas, it is reasonable to investigate this aspect also for all developing countries to assess whether adaptation measures effectively address climate-related risks at a global level.

1.4. Objectives and Research Questions

Against this background, this Master's thesis seeks to address this issue by investigating whether current CCA measures, respectively the financing of such measures, are effectively addressing climate-related risks. This is achieved by analysing whether those climate-related hazards that have the greatest societal impact, and therefore cause the most suffering, are the main target of CCA strategies and funding. Thereby, the focus is on sudden-onset hazards, namely riverine floods, landslides, snow avalanches, and GLOFs. Regarding the study area, the analysis is carried out on a global level for developing countries. As this thesis intends to investigate the aforementioned research gap addressing mountain regions, it was decided to also conduct an analysis specifically for the countries in High Mountain Asia (HMA). This region was selected as a case study due to data availability and its representativeness for global mountain regions in terms of vulnerability and relevance associated with (cultural) ecosystem services.

In order to be able to carry out this investigation, various sub-objectives are pursued within the framework of this thesis:

A major goal is to obtain an overview of the risks associated with the climate-related hazards described above to which developing countries in general and HMA countries are exposed through data compilation. Since the aim is to identify those climate-related hazards that cause the most suffering, the focus of this analysis is set on the number of fatalities. This serves as an indicator for the societal impact of climate-related hazards, and thus, poses a proxy for risk. Other direct impacts (e.g. economic losses or intangible cultural losses) are not included.

A further objective is to investigate the funding allocation of adaptation projects according to the climate-related hazards that are addressed, while focusing once again on all developing countries and specifically on the countries of HMA. This analysis is based on the examination of the adaptation projects financed through two main international adaptation funds, namely the Green Climate Fund (GCF) and the Adaptation Fund (AF).

Based on these two analyses, the main objective of this thesis can be addressed by comparing the societal impacts (i.e. the number of fatalities) associated with climate-related hazards with the amount of adaptation funding invested in measures to tackle the same climate-related hazards. This helps to determine whether climate-related hazards, which cause a high number of fatalities and thus pose the greatest risk to sustainable development, are also associated with high adaptation funding. From this, it can be derived if certain climate-related risks are addressed by "too much" or "too little" adaptation financing relative to the observed impacts on society, and it can be discussed what other factors may drive the allocation of adaptation funding.

In this context, within the framework of this research, the following questions should be answered:

- What climate-related hazards represent the greatest risk to developing countries and specifically High Mountain Asia countries?
- How is adaptation funding, provided by the Green Climate Fund and the Adaptation Fund allocated among adaptation projects targeting specific climate-related hazards?
- How do the societal impacts (fatalities) from climate-related hazards assessed in the course of this Master's thesis align to the distribution of adaptation funding?
- What other factors influence the allocation of adaptation funding?

2. Theoretical Background

2.1. Climate Change

The burning of fossil fuels associated with the Industrial Revolution, has led to high emissions of greenhouse gases (GHGs), particularly since the 1950s. This has contributed to widespread changes to the Earth's climate, including rising temperatures (Haradhan, 2011) and shifts in precipitation patterns (Giorgi et al., 2019). Given that both temperature and precipitation are key climate factors relevant to riverine floods, landslides, snow avalanches, and GLOFs, this chapter discusses temperature and precipitation trends and future projections both on a global scale and specifically for mountain regions. Additionally, it is also discussed how these changes impact on snow cover, glaciers and permafrost. While primarily referring to the IPCC report as a scientific basis, this chapter therefore provides a foundation for understanding the role of climate change in affecting the occurrence and intensity of the four natural disasters under investigation.

2.1.1. Global

Temperature Trends and Future Projections

Since 1970, the rate of increase in global surface temperature has been greater than ever before, exceeding that of any 50-year time span in the past 2,000 years. Between 2011 and 2020, the global surface temperature rose by around 1.1°C compared to the period 1850-1900, with a lower rate of warming over the ocean (0.88°C) than over land (1.59°C). The contribution of human activities to this increase is estimated to be 1.07°C from 1850-1900 to 2010-2020 (IPCC, 2023a). In terms of temperature extremes, the IPCC AR6 report indicates "(…) an increase in the number of warm days and nights and a decrease in the number of cold days and nights on the global scale since 1950" (Seneviratne et al., 2021, p. 1550), while the coldest as well as the hottest extremes are marked by increasing temperatures. Regionally, these changes can be observed in North America, Asia, Australasia and Europe. On a global scale, it can be further stated that heatwaves are becoming more intense and longer in duration, and that there is a higher number of heatwave days, which is also evident at a regional scale in Asia, Australia and Europe (Seneviratne et al., 2021). Furthermore, "there is medium confidence in similar changes in temperature extremes in Africa and high confidence in South America" (Seneviratne et al., 2021, p. 1550).

Future global temperature trends will be determined by the level of GHG emissions, with the total amount of CO_2 accumulated over time playing the most important role (IPCC, 2023b). In the IPCC AR6 report it is stated that "the assessed best estimates and very likely ranges of warming for 2081-2100 with respect to 1850-1900 vary from 1.4 [1.0 to 1.8]°C in the very low GHG emissions scenario (SSP1-1.9) to 2.7 [2.1 to 3.5]°C in the intermediate GHG emissions scenario (SSP2-4.5) and 4.4 [3.3 to 5.7]°C in the very high GHG emissions scenario (SSP5-8.5)" (IPCC, 2023b, p. 68). At the regional level, Figure 1 illustrates that under different global warming scenarios[1] (1.5°C, 2°C, and 4°C), the Arctic and especially the Antarctica are projected to experience particularly large temperature increases, while the tropics will experience less warming in direct comparison. Furthermore, the temperature increase over land will be greater than over sea (IPCC, 2021).

[1] Generally, the more global temperatures rise, the more severe the effects of climate change are expected to be, as well as the losses and damages associated with it. Furthermore, greater temperature increases will also lead to more complex climate-related risks, which will become increasingly challenging to tackle (IPCC, 2023b). As part of the Paris Agreement, it was therefore internationally agreed to hold "(…) the increase in the global average temperature to well below 2°C above pre-industrial levels (…) and to pursue efforts "(…) to limit the temperature increase to 1.5°C above pre-industrial levels (…)" (UN, 2015a, p. 3).

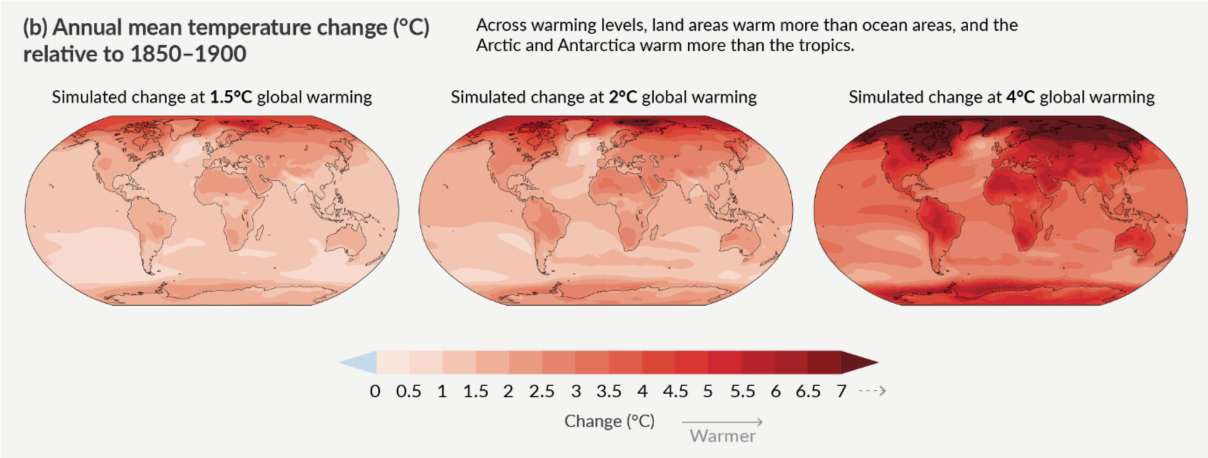

Figure 1: *The change in annual mean temperature (°C) compared to 1850-1900, focusing on three different global warming scenarios (1.5°C, 2°C, and 4°C) (taken from IPCC, 2021).*

Focusing again on temperature extremes, on a global scale it is generally expected that during the current century hot extremes will become more intense and more frequent, while cold extremes will tend to continue to decline in their intensity and frequency. Furthermore, most land areas will experience more hot days and hot nights, while heatwaves or warm spells will become longer, more frequent and more intense (Seneviratne et al., 2021). According to the IPCC AR6 report, there is high confidence that "in most regions, changes in the magnitude of temperature extremes are proportional to global warming levels" (Seneviratne et al., 2021, p. 1557).

Precipitation Trends and Future Projections

Precipitation is significantly influenced by global warming. While evaporation intensifies with rising temperatures, the capacity of the atmosphere to hold moisture also increases (7% for each °C of warming), resulting in higher concentrations of atmospheric water vapor (Trenberth, 2011). This has contributed to an increasing trend in global average precipitation (Giorgi et al., 2019). Thus, the IPCC AR6 report specifically identifies a likely increase in average global precipitation over land since the mid-20th century, which has become stronger since the 1980s (IPCC, 2021). Assessing regional changes in precipitation is more complex, as they are coupled with alterations in, for example, global circulation patterns, global energy budgets, or non-climatic factors, such as land use and topography (Giorgi et al., 2019). In general, however, most parts of the world are experiencing annual precipitation increases, while a smaller number of regions are facing a decrease (Caretta et al., 2022). With regard to heavy precipitation, there is high confidence that these events have become more intense and frequent globally since the 1950s over most of the world's land surface (IPCC, 2021). However, in some parts of the world, such as western Africa, northeastern South America and eastern Australia, a downward trend in heavy precipitation events was recorded (Caretta et al., 2022).

In terms of future precipitation projections, the IPCC AR6 report indicates an increasing trend for areas within the monsoon zones, the equatorial Pacific and for high latitudes, but a decreasing trend for parts of the subtropics and small regions within the tropics (see Figure 2) (IPCC, 2021). However, providing accurate projections of changes in precipitation are difficult due to uncertainties in global climate models. For example, under a high GHG emissions scenario, the increase in global annual average precipitation is expected to be in the range of 2% to 10% by the end of this century (Thackeray et al., 2022). With regard to heavy precipitation, various sources project that these events will become more intense and more frequent (e.g. Thackeray et al., 2022; Zhang & Villarini, 2017). According to the IPCC AR6 report, "at 1.5°C global warming, heavy precipitation and associated flooding are projected to intensify and be more frequent in most regions in Africa and Asia (high confidence), North America (medium to high confidence) and Europe (medium confidence)" (IPCC, 2021, p. 24). The certainty and severity of heavy (and mean) precipitation would increase further under a ≥ 2°C global warming scenario. Additionally, if global warming reaches 4°C, rare heavy precipitation events that typically occur every 10 years (or even more rarely) are projected to increase in frequency and intensity, not only at global but also at the continental and regional scales (IPCC, 2021).

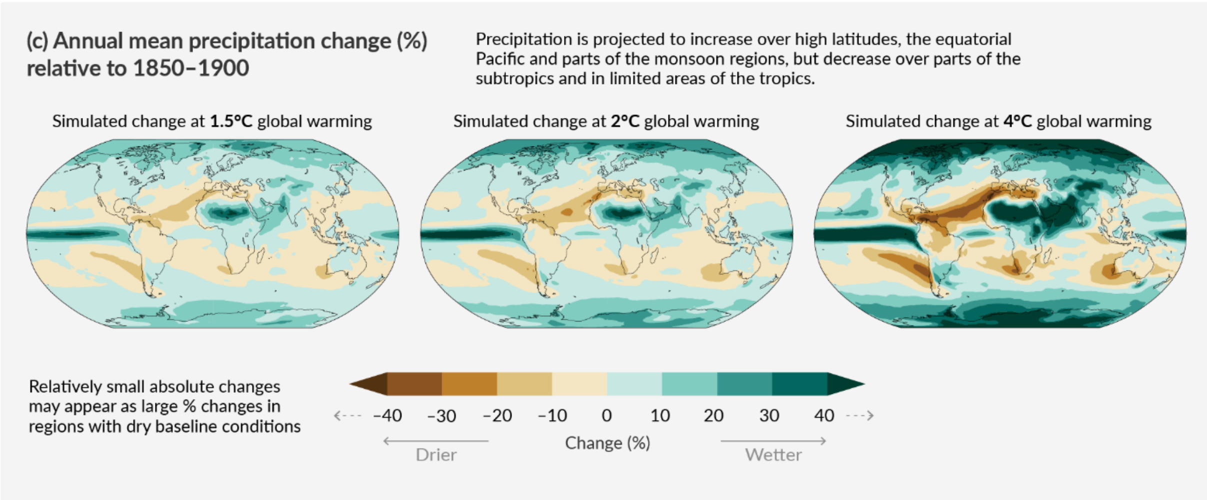

__Figure 2:__ A global overview of the change in annual mean precipitation compared to 1850-1900, focusing on different global warming scenarios (1.5°C, 2°C, and 4°C) (taken from IPCC, 2021).

2.1.2. Mountain Regions

Temperature Trends and Future Projections

According to the IPCC report, "mountain surface air temperature observations in Western North America, European Alps and HMA show warming over recent decades at an average rate of 0.3 °C per decade, with a likely range of +/- 2°C, thereby outpacing the global warming rate 0.2 +/- 0.1 °C per decade" (Hock et al., 2019b, p. 137). Globally, studies found that areas above 500 m a.s.l. generally experience stronger warming compared to lower elevations (Qixiang et al., 2016, 2018), however, regionally and locally, the IPCC summarises that warming rates in dependence on the elevation vary greatly among studies and are sometimes contradictory. It is also important to note that the rate of warming at the local level is seasonally dependent (Hock et al., 2019b). Thus, according to a study conducted by You et al. (2010), the Tibetan Plateau shows higher warming rates in winter, while, for example, Auer et al. (2007) highlights greater warming increases in summer and spring for the European Alps.

The IPCC report recognizes that human influence is likely to be the predominantly driving force behind the increase in surface air temperatures experienced since the 1950s in high mountain areas (Hock et al., 2019b). Further, it attributes very high confidence to the prediction that "until the mid-21st century, regardless of the climate scenario, surface air temperature is projected to continue increasing (…) at an average of 0.3°C per decade, with a likely range of +/- 0.2°C per decade, locally even more in some regions, generally outpacing global warming rates (0.2 +/- 0.1°C per decade)" (Hock et al., 2019b, p. 138). Similar to the predictions on a global level, there is very high confidence that in the latter half of the 21st century, mountain regions will experience higher warming rates if GHG emissions remain high (RCP8.5 scenario). However, if the GHG emissions are kept low (RCP2.6 scenario), the warming is expected to stabilise at the level of the mid-21st century (Hock et al., 2019b).

Precipitation Trends and Future Projections

Unlike temperature changes, historical shifts in precipitation in mountain regions are not as precisely documented and are marked by greater heterogeneity, even within mountain regions. Therefore, no clear trends with respect to annual precipitation patterns have been observed for mountain regions over recent decades. However, the IPCC report concludes that there has been a decline in snowfall, particularly at lower altitudes, which is partially attributable to increased temperatures (Hock et al., 2019b).

In terms of future projections, the IPCC report indicates, with medium confidence, that there will be "increases [in annual precipitation] of the order of 5 to 20% over the 21st century in many mountain regions, including the Hindu Kush and Himalaya, East Asia, eastern Africa, the European Alps and the Carpathian region, and decreases in the Mediterranean and the Southern Andes" (Hock et al., 2019b, p. 139). The projections of future changes regarding extreme precipitation events, including their frequency and intensity, show regional and seasonal differences (Hock, Rasul, et al., 2019). For example, it was found that parts of the southeastern Himalaya as well as the Tibetan Plateau will face intensified summer monsoon precipitation by the order of approximately 22% over this century assuming a high emissions scenario (RCP8.5) (Sanjay et al., 2017). With regard to snowfall, the IPCC report attributes very high confidence to the statement that lower elevations are predicted to be confronted with decreasing trends, both near term (2031-2025) and long term (2081-2100), irrespective of the GHG emission scenario. At higher altitudes, there is medium confidence that the increase in temperature is not significant enough to alter the division between rain and snow, which is why greater winter precipitation totals may result in increased snowfall (Hock, Rasul, et al., 2019).

Impacts on Snow Cover

According to the IPCC report, "at lower elevation, there is high confidence that the mountain snow cover has generally declined in duration (on average by 5 snow cover days per decade, with a likely range from 0 to 10 days per decade), mean snow depth and accumulated mass (snow water equivalent) since the middle of the 20th century, with regional variations" (Hock, Rasul, et al., 2019, p. 140). Various sources associate this trend with the shift from solid to liquid precipitation and enhanced melting rates, most of which is driven by higher air temperatures (e.g. Kapnick & Hall, 2012). However, with regard to higher altitudes, the IPCC states that "(…) snow cover trends are generally insignificant (medium confidence) or unknown" (Hock, Rasul, et al., 2019, p. 140).

Regarding future projections, the IPCC report indicates a reduction of snow depth and mass by 25% between 1986-2005 and 2023-2050 for low lying areas, including in the Himalayas, subtropical Andes, Western North America as well as in the European Alps for all greenhouse gas emission scenarios. Thus, the observed declination of snow cover duration is predicted to persist in the future (Hock, Rasul, et al., 2019). For the period 2081-2100, the IPCC highlights that "(…) reductions of up to 80% (likely range from 50 to 90%) are expected under RCP8.5, 50% (likely range from 30 to 70%) under RCP4.5 and 30% (likely range from 10 to 40%) under RCP2.6" (Hock et al., 2019b, p. 140). When looking at higher altitudes, it is predicted that the reductions observed there will be less severe as snowfall in winter is expected to increase (see above), resulting in an overall gain of snow mass in winter. Irrespective of the altitude and region, snow conditions will show consistent year-to-year variability throughout the current century (Hock et al., 2019b).

Impacts on Glaciers

Despite significant annual fluctuations and regional differences (Hock et al., 2019b), there has been a general global retreat of mountain glaciers in recent decades (Zemp et al., 2015). The IPCC report states that between 2006 and 2015, mountain glaciers globally lost around 490 (+/- 100) kg of mass per m^2 each year. This, however, excludes glaciers in the Canadian and Russian Arctic, Svalbard, Greenland

and the Antarctica. The glaciers in HMA experienced the smallest loss with approximately 150 (+/- 110) kg of mass per m^2 each year, although there was considerable variation within the region. In terms of total mass loss, the highest values were recorded in Alaska, with the Southern Andes and HMA also showing significant decreases, which can be attributed to the considerable ice extend in these regions (Hock et al., 2019b). According to Zemp et al. (2019), the average global loss of glacier mass shows an increase of approximately 30% from the period 1986-2015 to the period 2006-2015. Based on the IPCC, "it is very likely that atmospheric warming is the primary driver for the global glacier recession [and] there is limited evidence (high agreement) that human-induced increases in greenhouse gases have contributed to the observed mass changes" (Hock et al., 2019b, p. 142).

In general, the glacier retreat already observed in high mountain regions is predicted to continue throughout the current century (Hock et al., 2019a). According to a study conducted by Hock et al. (2019a), compared to 2015 levels, global glacier mass (excluding the two major ice sheets) is projected to decrease by 18% (+/- 7%) under the RCP2.6 scenario and by 36% (+/- 11%) under the RCP8.5 scenario by the end of the 21st century. Although there are significant variations in projections depending on the region and the glacier models (Hock et al., 2019a), the highest projected average mass loss values are more likely to be expected in mountainous regions with small glaciers and limited ice cover (e.g. European Alps, Caucasus, or North Asia) (Hock et al., 2019b).

Impacts on Permafrost

Generally, "permafrost describes the condition of earth material (sand, ground, organic matter, etc.) cemented by ice when its temperature remains at or below 0°C continuously for longer than 2 years" (Abramov et al., 2021, p. 1). According to the IPCC report, there is high confidence that "permafrost in the European Alps, Scandinavia, Canada, Mongolia, the Tien Shan and the Tibetan Plateau has warmed during recent decades (…)" (Hock et al., 2019b, p. 145) and that some observations indicate permafrost degradation as well as a reduction in ground ice. However, as mountain regions are very diverse and there is lack of long-term observations, it is difficult to determine permafrost warming rates at the global and regional scale accurately (Hock et al., 2019b). Nevertheless, some studies focused on this issue, for example, Biskaborn et al. (2019), who determined the average permafrost warming rate between 2007 and 2016 to be 0.19 +/- 0.05°C per decade for a total of 28 mountain sites covering Canada, Scandinavia, the European Alps, North Asia, and HMA. With regard to the HMA region, it is worth noting that research on permafrost in general is largely centred on the Qinghai-Tibetan Plateau, while other subregions, such as the Hindu Kush Himalaya (HKH), have been given comparatively less attention (Baral et al., 2023). In addition to general permafrost warming, numerous studies have also shown that the active layer[2] has thickened in recent decades across several mountain regions, including Scandinavia (Christiansen et al., 2010), the European Alps and the Tibetan Plateau, which suggests that permafrost is degrading (Hock et al., 2019b). According to the IPCC report, permafrost warming and degradation at the decadal scale is mainly the result of rising air temperatures, but is also influenced by altering soil moisture, vegetation, and snow cover conditions (Hock et al., 2019b).

In terms of future projections, it is possible to state with very high confidence, that "(…) permafrost in high mountain regions is expected to undergo increasing thaw and degradation during the 21st century, with stronger consequences expected for higher greenhouse gas emission scenarios" (Hock et al., 2019b, p. 146). For example, Lu et al. (2017) modelled future permafrost degradation on the Tibetan Plateau and found that under the RCP8.5 scenario, permafrost is expected to decline by approximately 64% before the end of this century. Nevertheless, simulations at finer scales show that warming and

[2] The active layer describes "(…) the layer of ground above permafrost subject to annual thawing and freezing (…)" (Hock et al., 2019b, p. 145).

degradation depend on region and altitude, and further highlight that warming rates may also show seasonal differences and variations between locations (Hock et al., 2019b).

2.2. Climate-Related Disasters

This chapter discusses the four climate-related disasters that are relevant to this thesis and, in particular, aims to demonstrate how they are related to climate change. Each climate-related hazard is covered in a subchapter, beginning with a description of the hazard process and then explaining how it is driven by climate change, while also focusing on current trends and future projections. In addition, at the end of each subchapter, there is a brief explanation of how and whether fatalities caused by each type of hazard can be attributed to climate change.

2.2.1. Riverine Floods

Hazard Description

Riverine floods occur "(…) when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow (…) [as a consequence of which] (…) water overflows the banks, spilling out into adjacent low-lying, dry land" (FEMA, n.d.). Various river and catchment systems around the world are affected by riverine floods (UNDRR, n.d.-b), which are usually driven by soil moisture excess, snowmelt, or heavy precipitation (Berghuijs et al., 2019). In general, larger river basins are mainly subject to riverine floods resulting from prolonged and heavy rainfall, while regions in high latitudes are affected by snowmelt floods, occasionally exacerbated by rain or ice jams. Regarding small basins, they may be affected by riverine floods from short, but extremely intense rainfall (Kundzewicz et al., 2014). However, it has to be mentioned that there are also various non-climate-related factors that influence riverine floods, which is elaborated below (Seneviratne et al., 2021).

Figure 3: *Flooding of the River Doubs in St-Ursanne (Canton of Jura, Switzerland) at the end of January 2018 (taken from Mobiliar Lab für Naturrisiken / Multirotors Team, 2018).*

Trends, Drivers, and Future Projections

The assessment of riverine flood trends is generally challenging, especially at the global scale (Liu et al., 2022), which complicates attempts to attribute such patterns to climate change (Scussolini et al., 2023). This is also highlighted by the IPCC AR6 report, stating that "(…) hydrological literature on observed flood changes is heterogeneous, focusing at regional and sub-regional basin scales, making it difficult to synthesize at the global and sometimes regional scales" (Seneviratne et al., 2021, p. 1568).

Given that heavy rainfall is increasing (see Chapter 2.1) (IPCC, 2021), it might be expected that riverine floods are also increasing (Wasko & Nathan, 2019). However, various scientists are still debating if and to what degree rising trends in heavy rainfall can be translated into changing riverine flood patterns (Zhang et al., 2022). Recent findings suggest that, on a global scale, riverine floods are generally decreasing, since decreasing antecedent soil moisture outweighs increasing heavy rainfall trends (Liu et al., 2022; Wasko & Nathan, 2019). However, the magnitude of riverine floods associated with rare, particularly heavy rainfall events has increased because, in such cases, the reduction in antecedent soil moisture is outweighed by the volume of heavy rainfall (Wasko et al., 2021; Wasko & Nathan, 2019). As previously stated, snowmelt is also an important factor in the occurrence of riverine floods, but its global influence is considered to be less significant than that that of heavy rainfall and soil moisture. Nevertheless, in high latitudes, where snowmelt has a more pronounced impact, changes in snowmelt conditions have been found to drive a decreasing trend in riverine floods (Liu et al., 2022).

At the regional level, riverine floods exhibit both increasing and decreasing trends. The IPCC AR6 report summarises the results of various regional studies by focusing on peak flows as an indicator (Seneviratne et al., 2021). In general, regions that experience a decrease in soil moisture also show a decrease in peak flow magnitude (i.e. in riverine floods) (Wasko & Nathan, 2019). Thus, according to the report, "(…) there are regions experiencing increases, including parts of Asia, Southern America, north-east USA, north-western Europe, and the Amazon, and regions experiencing decreases including parts of the Mediterranean, Australia, Africa, and south-western USA" (Seneviratne et al., 2021, p. 1568). The IPCC AR6 report also highlights a shift in the seasonality of peak flows which was observed in cold regions where the flow regime is dominated by snowmelt (Seneviratne et al., 2021). This was, for example, highlighted by Blöschl et al. (2017) for northeastern Europe, where it was found that riverine floods associated with spring snowmelt occur earlier due to increased temperatures.

Nevertheless, it has to be mentioned that riverine floods are not only determined by climate-related factors (i.e. heavy rainfall, soil moisture, and snowmelt) (Scussolini et al., 2023), but also by "(…) the stream morphology, river and catchment engineering, land-use and land-cover characteristics and changes, and feedbacks between climate, soil and snow, vegetation (…)" (Seneviratne et al., 2021, p. 1567). Therefore, the impact of climate change (e.g. of increased heavy precipitation) can either be damped, outweighed or amplified by these other factors (Scussolini et al., 2023).

Against this background, it is also difficult to give accurate predictions about future riverine flood trends. Where snowmelt (combined with heavy and/or prolonged precipitation) is a major driver of severe and widespread river flooding, predicting how floods will change in these areas is particularly challenging due to the complex and sometimes conflicting ways that snow and rain respond to rising temperatures, which in turn affect the amount of snow on the ground (Seneviratne et al., 2021). However, on a global scale, studies generally indicate that riverine floods will become more frequent and intense in the face of climate change (e.g. Willner et al., 2018). As it is assumed that extreme precipitation may become a leading factor for riverine floods (Seneviratne et al., 2021), some studies indicate that specifically extreme riverine flood events are expected to occur much more frequently in the future (Alfieri et al., 2017). For example, Alfieri et al. (2017), focusing on global riverine flood projections for individual continents, assessed that in Africa, extreme riverine flood events, currently observed theoretically once every 100 years (in reality every 185 years), will occur once every 40 years under the 1.5°C and 2°C scenarios, and once every 21 years if warming reaches 4°C. With regard to predicting regional changes, the IPCC AR6 report states that riverine floods are associated with greater uncertainty than pluvial floods, which are more directly driven by precipitation (Seneviratne et al., 2021). In general, studies show that there are considerable variations with regard to future riverine flood activity at narrow scales (Dankers et al., 2014; Hirabayashi et al., 2013). However, the IPCC AR6 report indicates with medium confidence that "(…) a larger fraction of land areas [is going] to be affected by an increase in river floods than by a decrease in river floods" (Seneviratne et al., 2021, p. 1518). Thereby, an increasing trend in magnitude and frequency of riverine floods is forecast for western Amazon and the Andes in South America, the high latitudes of North America, eastern and tropical Africa, and South-eastern and northern Asia and India. Conversely, decreasing trends are projected for central and eastern Europe and the Mediterranean, and parts of South America, southern and central North America, and south-west Africa (Seneviratne et al., 2021).

Drivers of Human Losses from Riverine Floods

As in the case of riverine flood trends, the human losses caused by riverine floods cannot be linked solely to climate change. Visser et al. (2014) and Dottori et al. (2018) note that the observed increasing impacts of riverine floods are mainly due to changes in human exposure (e.g. due to population growth) in flood-prone areas. However, they both also highlight that the impact of climate change cannot be neglected in this regard (Dottori et al., 2018; Visser et al., 2014). Concerning future projections, Dottori et al. (2018) recognizes that socio-economic changes will play a key role in determining riverine flood risk and therefore the number of fatalities. Accordingly, Dottori et al. (2018) assessed global future losses due to riverine floods, using different warming and socio-economic scenarios, while taking into account the current flood protection measures and vulnerability situations. Based on this analysis, the number of fatalities due to riverine floods is estimated to increase by 70 to 83% under 1.5°C warming, and by another 50% under 2°C warming at the global level, in dependence on the socio-economic scenario. If warming reaches 3°C, the impacts of riverine floods further increase, but with greater uncertainty (Dottori et al., 2018).

2.2.2. Landslides

Hazard Description

The definition of the term "landslide" encompasses various processes resulting "(…) in the downward and outward movement of slope-forming materials, including rock, soil, artificial fill, or a combination of these" (UNISDR, 2017, p. 2). Thereby, the material either falls, topples, slides, spreads or flows or alternatively, exhibits a combination of these movement types (see Figure 4) (BGS, n.d.). The destructiveness of a landslide is determined by the velocity of the material as well as the volume, which can range from a small individual boulder up to millions (or even billions) of cubic metres. However, it must be taken into account that even the impact of an individual boulder can result in considerable number of deaths (UNISDR, 2017).

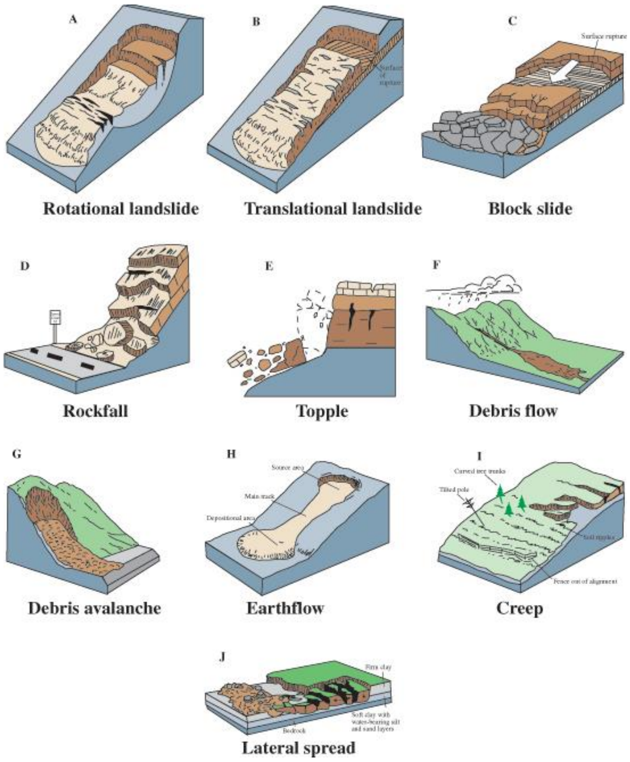

Figure 4: *Schematic illustration of the most important landslide movement types (taken from USGS, 2004).*

In most cases, landslides are triggered by one or a combination of three natural mechanisms, namely water, seismic activity and/or volcanic activity (Highland & Bobrowsky, 2008). The slope movement is primarily driven by gravity exerting a down-ward force on unstable slope sections (USGS, n.d.). It has to be mentioned that slope stability is a key determinant of landslide activity, which is directly and/or indirectly influenced by natural and non-natural factors (see below) (Highland & Bobrowsky, 2008; UNISDR, 2017).

Figure 5: *Landslide in La Conchita (California, United States) in January 2005 (USGS, 2016).*

Trends, Drivers, and Future Projections

The link between enhanced landslide activity and climate change has been established by various studies (Svennevig et al., 2024). As indicated above, a key aspect in the context of landslide activity is slope stability (UNISDR, 2017), which is influenced by numerous factors that often interact with each other (Patton et al., 2019). Some of these factors are directly related to climate and therefore influenced by climate change (Patton et al., 2019), for example heavy rainfall and rapid snowmelt, which can lead to rock or soil destabilization due to water saturation, as well as floods, or thawing processes (Highland & Bobrowsky, 2008; UNISDR, 2017).

However, attributing landslide trends to climate change is not straightforward. Generally, landslides are highly diverse and complex, leading to varying responses to climate change depending on the type of landslide (Gariano & Guzzetti, 2022). Furthermore, there is just a partial overlap of climate and landslides with regard to their temporal and spatial dimensions at which they occur, making it difficult to clearly assess how climate (change) affects landslides (Gariano & Guzzetti, 2016). Additionally, slope stability is further influenced by other non-climatic factors, such as topographical aspects (e.g. slope angle) and geological aspects (e.g. strength of rock mass and structural characteristics) (Huggel et al., 2012). Moreover, there are numerous factors associated with human activity, which may influence landslide activity by affecting slope stability (Gariano & Guzzetti, 2016). Examples include mining (BGS, n.d.), forestry and agricultural practices, as well as changes in land cover and land use (Gariano & Guzzetti, 2016), of which deforestation and road cutting are particularly noteworthy (Muñoz-Torrero Manchado et al., 2021, 2022). Some of these factors may also be directly and indirectly influenced by global warming. Against this background, the significant number of natural and human related factors, as well as the multi-facetted interactions and feedbacks between them, also contribute to the fact that the precise impact of climate change on slope stability and thus on landslides is still debatable (Gariano & Guzzetti, 2016).

Nevertheless, there are some basic scientific findings about how climate change affects landslide trends in general. Globally, intense and long-duration rainfall is the most common cause of landslides. In view of climate change, research indicates a link between higher levels and intensities of precipitation and increased landslide activity (Kirschbaum et al., 2012). In certain regions, temperature changes are also a crucial factor in influencing the occurrence of landslides, especially in high mountain areas (Pei et al., 2023). As a consequence of climate warming, ice and snow begin to melt, resulting in the formation of liquid water that can subsequently trigger landslides (Huggel et al., 2010). Furthermore, rising temperatures can cause permafrost thawing, which affects groundwater dynamics, friction, and cohesion of materials close to the surface, with subsequent effects on landslide processes (Patton et al., 2019, 2021). The IPCC AR5 report also associates current landslide trends in high mountain areas with permafrost changes by indicating with high confidence "(…) that the frequency of rocks detaching and falling from steep slopes (rock fall) has increased within zones of degrading permafrost over the past half-century, for instance in high mountains of North America, New Zealand, and Europe" (Hock et al., 2019b, p. 158). Another important process relevant in high mountain regions is glacier retreat. It was found that slopes that are revealed after a glacier has retreated, become unstable after some time which leads to increased landslide activity (Hock et al., 2019b). Thus, according to the IPCC AR5 report, "there is high confidence that glacier retreat in general has in most high mountains destabilised adjacent debris and rock slopes over time scales from years to millennia (…)" (Hock et al., 2019b, p. 158). However, there are no robust statistics regarding the latest trends in this development (Hock et al., 2019b).

With regard to future projections, several studies predict an increase in landslide activity due to climate change. For example, a global study found that "(…) compared to the 30-year period from 1971 to 2000, the average annual frequency of landslides triggered by extreme precipitation is predicted to increase by 7% to 10%, respectively, in the future 30-years periods of 2031-2060 and 2066-2095" (Wang et al., 2023, p. 751). At the regional level, studies assessed a similar trend. For example, Kirschbaum et al. (2020) predicts that landslides will occur more often in HMA (Nepal, Tibet and China) due to increased rainfall frequency and intensity (Kirschbaum et al., 2020). With regard to landslides related to temperature changes, large slope failures in high mountain regions are expected to occur more often due to increased snow and ice melt (Huggel et al., 2010) and the continued thawing of permafrost is likely leading to an increase in the magnitude and frequency of landslides (Patton et al., 2019).

Drivers of Human Losses from Landslides

In terms of whether and how fatalities caused by landslides are driven by climate change, studies have shown similar results to those obtained for riverine floods. For example, Petley (2010) acknowledges the key role of climatic triggers (e.g. heavy monsoon rainfalls), but also highlights the relevance of population growth when it comes to landslide-related losses. Moreover, he assigns greater importance to socio-economic development (Petley, 2010), which affects both vulnerability and exposure (Taylor et al., 2023), than to climate change with regard to future landslide losses (Petley, 2010).

2.2.3. Snow Avalanches

Hazard Description

Snow avalanches can be described as "(…) rapid gravity-driven masses of snow moving down mountain [or hill] slopes" (Ancey, 2001, p. 2), that can be observed across mountain ranges on all continents and climatic zones. They may occur at sea level in polar zones or at heights of up to 6,000 m a.s.l. in tropical zones (Glazovskaya, 1998). In general, snow avalanches often extend over a few hundred meters and move at a relatively slow speed of a few hundred meters per second. However, they have also been observed to travel up to 15 km and reach speeds of up to 100 m/s. In addition, it is noteworthy that snow avalanches can build up an incredible pressure of up to several atmospheres (Ancey, 2001).

Snow avalanches occur as a result of an interplay between the snow pack, terrain (e.g. inclination, surface roughness, etc.), and weather (e.g. precipitation, wind, temperatures, etc.) (Ancey, 2001; Schweizer et al., 2003). They may be spontaneously released from meteorological factors (e.g. new snow or liquid water infiltration) or they can also be triggered by external factors. Examples include falling rocks and ice, or human activities that either accidentally lead to avalanche releases (e.g. recreationists or workers in the avalanche terrain) or deliberately through avalanche blasting (Hock et al., 2019b; Schweizer et al., 2003). While naturally triggered snow avalanches pose a threat to residence and infrastructure, human induced avalanches endanger for the most part recreationists (Schweizer et al., 2003).

Figure 6: *Massive snow avalanche that occurred in the Eagle River region near Anchorage (Alaska, United States) on the night of the 24th of March 2022 (taken from Bronson, 2022).*

Trends, Drivers, and Future Projections

As mentioned above, the release of snow avalanches is a result of various factors, namely the snow pack, the terrain, and the weather (Ancey, 2001; Schweizer et al., 2003). In addition to the fact that long and complete regional snow avalanche records are generally limited (Gądek et al., 2017), these two aspects make it challenging to investigate how climate change effectively influences snow avalanches (Gądek et al., 2017; Mayer et al., 2024). According to the IPCC report, “there is no published evidence found that addresses the links between climate change and accidental [snow] avalanches triggered by recreationists or workers” (Hock et al., 2019b, p. 159). However, it was found that natural snow avalanches that occur spontaneously are influenced by climate change (Hock et al., 2019b), among other things with regard to their spatial occurrence, frequency, magnitude, and flow regime (e.g. dry or wet avalanches) (Mayer et al., 2024).

This has been highlighted by numerous studies focusing on current snow avalanche trends. For instance, in the Western Himalayan region of India, an increase in avalanches involving wet snow has been observed, that was linked to rising winter and early spring air temperatures. These snow avalanches have a high damage potential as they can extend to lower lying subalpine areas. This example illustrates that increasing temperatures leading to reduced snow masses are not necessarily accompanied by fewer snow avalanches (Ballesteros-Cánovas et al., 2018). According to various studies focusing on the European Alps, a similar trend has been observed for the last decades. Thus, while powder-snow (dry) avalanches decreased, wet-snow avalanches became proportionally more frequent between December and February. Furthermore, a reduction in the mass as well as the run-out distance of avalanches was observed. Generally, below an elevation of 2,000 m a.s.l., fewer snow avalanches were recorded, while higher elevations were marked by an increased number of snow avalanches (Hock et al., 2019b).

According to the IPCC report, “(…) there is medium evidence and high agreement that observed changes in avalanches in mountain regions will be exacerbated in the future (…)” (Hock et al., 2019b, p. 161). It is predicted that lower elevations will be dominated by decreasing snow depth as well as snow cover duration, although the chance of sporadic heavy snowfall events will still be possible for the greater part of this century. In areas and altitudes where the snow cover is substantially decreasing, the total number of snow avalanches as well as the distance they travel are expected to reduce (Hock et al., 2019b), which is why the IPCC generally indicates “(…) a decrease in [snow avalanche] hazard at lower elevation (…)” (Hock et al., 2019b, p. 161). This is underpinned by several studies, for example by Mayer et al. (2024) indicating that the overall avalanche activity in the Swiss Alps between December and May is predicted to decrease in areas lower than 2,200 m a.s.l. by the end of the current century. However, with regard to future snow avalanche activity at higher elevations, the results of the studies are in some cases inconsistent (Mayer et al., 2024). In the study conducted by Lavigne et al. (2015) it is argued that factors such as high temperatures during the winter months as well as more frequent heavy snowfall events in the higher elevations of the Alps may result in increased snow avalanche activity (Lavigne et al., 2015). However, Mayer et al. (2024) do not support this finding and propose instead that snow avalanches will gradually stop occurring in increasingly higher altitudes if GHG emissions are not mitigated.

In terms of the flow regimes of snow avalanches, Mayer et al. (2024) found that dry-snow avalanches are going to decrease irrespective of the elevation during the months between December and May, which is to a certain extend balanced by a higher frequency of wet-snow avalanches. Furthermore, the seasonality of wet-snow avalanches shifts due to climate change with the period of maximum wet-snow avalanche activity occurring earlier, while the activity of dry-snow avalanches mostly stays the same in this respect (Mayer et al., 2024). Another study conducted by Strapazzon et al. (2021) confirmed this finding and further highlights that especially higher elevations and continental regions might be confronted with wetter snow conditions arriving earlier in the winter season.

Drivers of Human Losses from Snow Avalanches

During the research for this thesis, it was found that the number of studies focusing on attributing snow avalanche fatalities to climate change is limited. According to Strapazzon et al. (2021), "at least 90% of avalanches that involve injury or death are triggered by recreationists" (Strapazzon et al., 2021, p. 2). However, as already mentioned in above, a link between such human-induced snow avalanches and climate change has not yet been established (Hock et al., 2019b). Instead, some scientists attribute observed increasing trends in snow avalanche fatalities to greater recreational activity (e.g. Jekich et al., 2016). With regard to the future threat posed by snow avalanches to villages, similarly to riverine floods and landslides, researchers generally emphasize the importance of socio-economic development (Strapazzon et al., 2021) and population growth in mountain regions (Stethem et al., 2003).

It is worth noting that one study was found, by Strapazzon et al. (2021), which specifically investigates how climate change may affect the chances of survival of snow avalanche victims. Thereby, the scientists particularly refer to the fact that climate change is leading to more wet snow avalanches (see above). On the one hand, wetter snow is characterized by higher snow density and thus lower oxygen variability which causes a faster oxygen desaturation and therefore lowers the survival rate of people buried in snow avalanches. On the other hand, climate change could also simultaneously increase avalanche survival which, however, has to be further examined in future research. It was found that the survival rate of people being buried below 120 cm of snow is five times lower than for people buried over 40 cm, no matter the duration of the burial. As climate change might lead to thinner snow packs, this can lead to a reduction of burial depth and thus, make survival more probable. However, the thinner snow covers as well as increased terrain roughness due to climate change is also likely to increase the risk of blunt trauma and secondary injuries. Trauma further leads to increased unconsciousness which lowers the chances of survival by making victims more susceptible to asphyxiation (Strapazzon et al., 2021).

2.2.4. Glacial Lake Outburst Floods

Hazard Description

Glacial lake outburst floods (GLOFs) describe "(…) the catastrophic release of a water reservoir that has formed either at the side, in the front, within, beneath or on the surface of a glacier" (Allen et al., 2017, p. 15). These water reservoirs are known as glacial lakes, originating from meltwater due to loss of ice and retreat of glaciers. They are either dammed by ice, moraine material or bedrock (Allen et al., 2017). In the past, GLOFs were often recorded in HMA, the Andes, and in the European Alps as well as in particular countries such as Iceland, Greenland, New Zealand, Russia, or in Scandinavian countries (Lützow et al., 2023).

GLOFs are marked by an abrupt, occasionally cyclic, water release from the glacial lakes. They often occur rapidly and may span from hours to several days. Further, GLOFs lead to substantial increases in downstream river flow, often multiplying the discharge significantly (Bendle, 2024). The release of the glacial lake water can either occur due to overtopping of the dam through a displacement wave, or due to dam failure. These mechanisms can be triggered by various processes (Emmer, 2017), for example by mass movements impacting the glacial lake, such as landslides, rockfalls, or avalanches. Furthermore, extreme weather conditions, particularly severe rainfall, can cause moraine dam degradation and lake overfilling (Sattar et al., 2021). Other possible trigger processes include melting ice in the dam, earthquakes, intense snowmelt, or long-term degradation of the dam (Emmer, 2017).

Figure 7: *A photograph of the Dig Tsho glacial lake in Nepal, taken in April 2009, showing the site of a devastating GLOF disaster in 1985 (taken from ICIMOD, 2011).*

Trends, Drivers, and Future Projections

There is broad agreement among scientists that climate change influences individual process chains of GLOF events (e.g. Gao et al., 2024; Riaz et al., 2014). As already mentioned above, the occurrence of GLOFs is coupled to glacial lakes resulting from glacier melt and retreat (Allen et al., 2017). Glaciers are intrinsically linked to the climate system (Huggel et al., 2020) and their melting and retreat is often used symbolically as a representation of climate change impacts. Raising temperatures do not only directly lead to increased melting, but also to a shift from solid to liquid precipitation, lowering the albedo of the glacier surface through reduced snow cover and thus contributing to increased melting rates (Bajracharya et al., 2007). As it takes decades or longer for glaciers to respond to altered climate conditions, it has to be mentioned that the currently observed glacier changes are a result of past and present climate variability and human-induced climate impacts (Marzeion et al., 2014). According to the IPCC report, there is high confidence that the "(…) current global glacier shrinkage caused new lakes to form and existing lakes to grow in most regions, e.g. South America, HMA and Europe" (Hock et al., 2019b, p. 161). Since the 1990s, glacial lakes have become more numerous and their volume and area have increased, which is linked to increasing temperatures associated with climate change. However, it is important to mention that there are also non-climatic factors that exert an influence in this respect. Thus, glacial lakes emerge from the complex interaction of factors related to climate, topography, geography and glaciers leading to variations in glacial lake growth at the regional level (Shugar et al., 2020).

Typically, GLOFs are defined by their magnitude and probability of occurrence, which are both influenced by various factors, for example the formation of glacier lakes (see above). Another important factor is dam stability, which is predominantly determined by geotechnical or geologic conditions, illustrating that factors influencing GLOF magnitude and probability are not exclusively associated with climate change (Huggel et al., 2020). Nevertheless, climate change can also have an impact on dam stability in a number of ways. For example, increased melting of snow and ice as a result of high temperatures, as well as heavy rainfall may result in large glacial lake volumes. This enhances the pressure on the dam, which could lead to dam damage or lake overflow (Gao et al., 2024). Furthermore, some moraine dams contain ice, which can melt due to rising temperatures, decreasing cohesion and leading to the dam's collapse. Unlike moraine-dammed glacial lakes, which generally burst out once, ice-dammed glacial lakes are characterized by cyclic water release and refilling. Climate change leads to thinner ice dams resulting in earlier outbursts (i.e. at lower water levels of the glacial lake). As the dams are getting thinner and thinner, the lakes fill and empty at a faster speed while the water volume reduces over time. Thus, the number of such events increases over time, but they are becoming less extreme as the stability of the ice dams decline (Veh et al., 2022, 2023). It is worth mentioning that in addition to dam stability, climate change can also affect outburst trigger mechanisms, as rising temperatures cause permafrost degradation, which can lead to unstable slopes around glacial lakes. This increases the likelihood of landslides, that could hit the lake and trigger an outburst (Huggel et al., 2020; Nussbaumer et al., 2014).

According to Harrison et al. (2018), the number of moraine-dammed GLOFs increased from 1930 to 1970, followed by a decline after 1970. The IPCC report also acknowledges the decreasing trend for moraine-dammed glacial lakes in recent decades and links it to the time lag between glacier retreat and corresponding GLOF activity while also highlighting that the documented number of GLOF events is likely to be considerable underestimated (Hock et al., 2019b). With regard to future projections, various scientists suggest that atmospheric warming could increase the yearly frequency of GLOFs (e.g. Harrison et al., 2018; Shugar et al., 2020). However, the extent to which climate change has led (and will lead) to a rising number of GLOFs is debated due to various reasons. Thus, the physical processes associated with GLOFs are not yet fully understood, while there are also shortcomings in models, and inconsistent data bases, which may also be biased towards regions with better data coverage and historical records. This is why the question was raised as to whether the observed increase in GLOFs is related to increased research in this area rather than to climate change (Veh et al., 2022). Nevertheless, the IPCC report indicates with high confidence that "(…) the number and area of glacier lakes will continue to increase in most regions in the coming decades, and new lakes will develop closer to steep and potentially unstable mountain walls where lake outbursts can be more easily triggered by the impact of landslides" (Hock et al., 2019b, p. 161).

Drivers of Human Losses from GLOFs

As with the other three climate-related hazards described above, GLOF fatality trends and future projections are shaped by a number of factors, not only climate change. This is highlighted for example by Taylor et al. (2023) who state that "countries with the largest, or most numerous, glacial lakes do not always possess a high GLOF danger. Instead (…) it is the exposed population that greatly elevates the potential impact of GLOFs globally" (Taylor et al., 2023, p. 4). In terms of future projections, Taylor et al. (2023) recognize that climate change significantly contributes to the danger caused by GLOFs through the formation and expansion of glacial lakes, but they also highlight other factors that need to be considered in this respect. This includes population migration and changing vulnerabilities as a result of socio-economic development. Another important aspect is the growth in tourism, along with the fact that hydropower and agriculture are moving to higher altitudes and in closer proximity to glacial lakes (Taylor et al., 2023).

2.3. Disaster Risk Concept

This chapter presents the IPCC's disaster risk concept (see Figure 8), which forms the basis of this thesis. The components of the concept are briefly explained and defined. It should be noted that some aspects have already been mentioned in the introduction, but are repeated here for completeness.

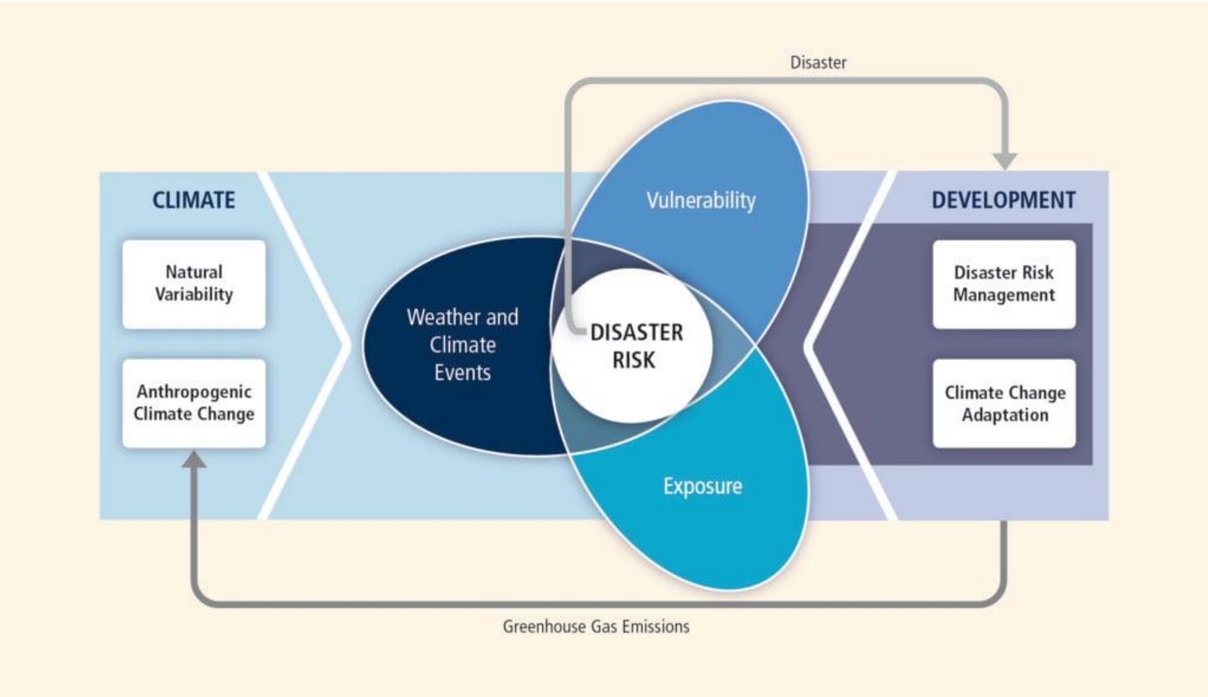

Figure 8: *Disaster Risk Concept of the IPCC (taken from IPCC, 2012b).*

In the context of this thesis, disasters are adverse impacts of weather and climate events that significantly disrupt the functioning of a community or society and result in environmental, economic, material or human impacts and losses (IPCC, 2022a). The IPCC defines the risk of such disasters as "the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions (…)" (IPCC, 2022a, p. 2906). As shown in the disaster risk concept of the IPCC (see Figure 8), disaster risk arises from the interaction of three components (IPCC, 2012a), which are defined below:

Hazards (i.e. weather and climate events) refer to "the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources" (IPCC, 2022a, p. 2911).

Vulnerability describes "the propensity or predisposition to be adversely affected. (…) [It] encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2022a, p. 2927).

Exposure is regarded as "the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected" (IPCC, 2022a, p. 2908).

The disaster risk concept of the IPCC emphasizes that weather and climate events are influenced by the climate (i.e. by climate variability and anthropogenic climate change) (IPCC, 2012a), as it may alter the intensity and severity of these type of hazards (see Chapter 2.2.) (Kohler et al., 2010). Further, the concept highlights that the degree of vulnerability and exposure is influenced by development processes, which could either lead to an increase or decrease in disaster risk (IPCC, 2012a). For example, rapid urbanisation combined with inadequate planning may increase the vulnerability and exposure of urban areas, thus leading to an increase in disaster risk (Rahman et al., 2012). At the same time, however, disasters can also negatively affect sustainable development through their social, economic or environmental impacts, which can include the loss of human lives and financial resources, infrastructure destruction or environmental degradation (Uitto & Shaw, 2016). According to the concept, there are two approaches (i.e. disaster risk management and climate change adaptation) to tackle disaster risks in the context of sustainable development by reducing vulnerability and exposure (IPCC, 2012a), which are elaborated in the following chapter.

2.4. Climate Change Adaptation and Disaster Risk Reduction

This chapter focuses on climate change adaptation (CCA) and disaster risk reduction (DRR), highlighting the similarities and differences between the two approaches and their importance in the context of addressing the increasing risk of climate-related disasters in the future.

Climate Change Adaptation

CCA emerged from scientific theory (ProAct Network, 2008) and encompasses "(…) adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects (…) to moderate potential damages or to benefit from opportunities associated with climate change" (UNFCCC, n.d.-a). This includes changes in structures, processes and practices (UNFCCC, n.d.-a). The focus of CCA is on building resilience[3] and reducing vulnerabilities specifically related to climate extremes (El-Ashry, 2009), aiming for sustainable development (Venton & La Trobe, 2008) with a future-oriented perspective (ProAct Network, 2008). It addresses new risks posed by a changing climate (ProAct Network, 2008) and relies on future climate scenarios and projections (Zein, 2017). CCA strategies generally involve observation, assessment, planning, implementation, as well as monitoring and evaluation (Zein, 2017).

Disaster Risk Reduction

In contrast, DRR has its roots in the humanitarian assistance provided after a disaster has occurred (ProAct Network, 2008). DRR is defined as "(…) the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the casual factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and poverty, wise management of land and the environment, and improved preparedness for adverse events" (UNISDR, 2009, p. 4). DRR focuses on existing ("old") risks and tackles vulnerabilities associated with all types of hazards, including non-climate-related risks, for example, earthquakes or volcanic eruptions. The application of DRR policies and strategies is called "disaster risk management" (UNDRR, n.d.-a), which includes three elements, namely pre-disaster response (prevention, mitigation and preparedness), disaster emergency response and post-disaster response (recovery and development) (Zein, 2017).

From these two descriptions, it is apparent that CCA and DRR are clearly distinct in their origins and focus, yet still overlap to some extent with regard to their objectives and scope (UNDRR, 2020). Generally, the common concern of CCA and DRR is the "increased frequency and/or intensity of climate-related hazards" (Turnbull et al., 2013, p. 7) (see Figure 9). In this context, both approaches "(…) seek to build resilience to hazards in the context of sustainable development (…) [and] (…) focus on reducing people's vulnerability to hazards by improving methods to anticipate, resist, cope with and recover from

[3] Resilience can be defined as "the capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure as well as biodiversity in case of ecosystems while also maintaining the capacity for adaptation, learning and transformation" (IPCC, 2022b, p. 7).

their impact" (Venton & La Trobe, 2008, p. 4). This ultimately contributes to a reduction in losses from climate-related disasters, including human fatalities (Venton & La Trobe, 2008).

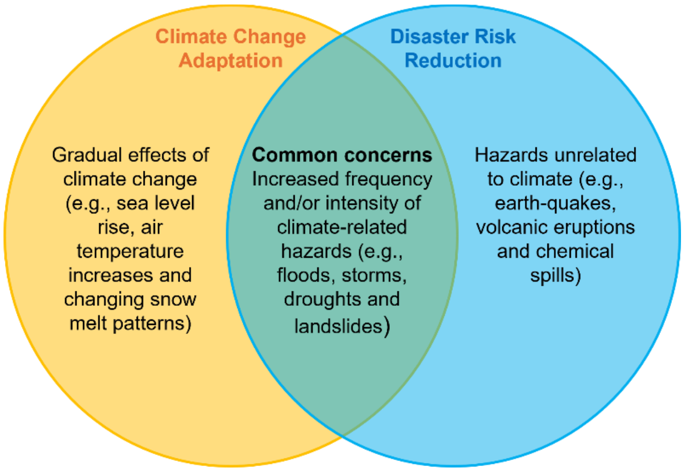

Figure 9: *Overlapping concerns of CCA and DRR (own illustration, based on Turnbull et al., 2013).*

It is important to note that, although both approaches are overlapping to some extend in their aim and scope, DRR and CCA are still administratively and institutionally separate and usually managed independently of each other (Clegg et al., 2019). However, several studies argue that combining CCA and DRR could lead to a considerable number of benefits, including greater efficiency of resource use as well as better decision-making through the exchange of knowledge (Begum et al., 2014). Therefore, the complexity of reducing risks and adapt in view of a changing climate can be better addressed through a collaboration between CCA and DRR (Schipper, 2009). Additionally, incorporating DRR and CCA helps to secure sustainable development, thereby driving the success of achieving the goals set by international frameworks, including the Paris Agreement[4], the Sendai Framework for Disaster Risk Reduction (SFDR)[5] and the Sustainable Development Goals (SDGs)[6] (Clegg et al., 2019).

2.5. Climate Finance

When the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992, it acknowledged that financial assistance was required for climate change mitigation and adaptation in developing countries (Khare, 2016; UNFCCC, n.d.-g). Based on the principle of "(…) common but differentiated responsibilities and respective capabilities" (CBDR-RC) (UN, 1992, p. 4), developed countries were called to financially support developing countries in climate-change related issues due to their greater financial and technological resources as well as their larger historical contribution to climate change (Khare, 2016). Building on this principle, the Convention established a climate finance system (UNFCCC, n.d.-g), that has expanded over the years into a complex, multi-layered mechanism and continues to evolve today (Watson et al., 2024). This chapter is dedicated to this climate finance mechanism, starting with a general definition and description of climate finance, followed by an introduction of the UNFCCC climate finance mechanism and concluding with a discussion of the two international climate funds that are relevant to this thesis.

[4] see footnote 1, p. 4

[5] The SFDR is an international agreement adopted at the Third UN World Conference in 2015 (Sendai, Japan), covering the period from 2015 to 2030 (UN, 2015b). Its goal is "the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries" (UN, 2015b, p. 12).

[6] The SDGs form the basis of the 2030 Agenda, which strives for sustainable development by fighting hunger and poverty, preventing the planet's degradation, and ensuring prosperity and peace. There is a total of 17 SDGs, which include 169 targets, that all member states of the UN must achieve by 2030 (UN, n.d.-b).

2.5.1. Definition

An internationally recognised definition of climate finance does not yet exist (Watson et al., 2024). However, the UNFCCC commonly describes it as "(…) local, national or transnational financing - drawn from public, private and alternative sources of financing - that seeks to support mitigation and adaptation actions that will address climate change" (UNFCCC, n.d.-e). Thereby, climate finance is usually provided through a variety of instruments, including guarantees, concessional loans, grants, or private equity (Watson et al., 2024).

Based on the definition above, local and national financing refers to funding flows within a country, while transnational financing describes funding flows across national borders (UNFCCC, n.d.-e). Transnational financial flows can be further divided into bilateral and multilateral flows. Thereby, bilateral refers to flows between two countries, while multilateral describes flows between more than two countries. More specifically, bilateral financing usually includes funds channelled directly to a recipient country (often a developing country) by a government (often from a developed country) (Ross, 2024), which may sometimes be supported by development cooperation agencies (UNFCCC, n.d.-c). Multilateral financing is often the aggregation of funds from different developed countries through an international organization (e.g. the World Bank) (Ross, 2024), or an international fund (e.g. GCF and AF) (Watson et al., 2024), which is then responsible for allocating the money to developing countries (Ross, 2024; Watson et al., 2024).

In terms of sources of climate finance, the majority of the funding originates from public sources. These include government budgets, financial resources of multilateral and bilateral financial institutions, and climate funds. Private sources of financing comprise, among others, funds and savings of non-profit organizations (e.g. Non-Governmental Organizations (NGOs)), cooperations or individuals (PPPLRC, 2023). Alternative sources of financing go beyond traditional forms of financing and may include, for example, crowdfunding (UNDP, n.d.-a).

2.5.2. The UNFCCC Finance Mechanism Architecture

The climate finance mechanism can be broadly divided into the UNFCCC finance mechanism and the non-UNFCCC finance mechanism[7] (Watson et al., 2024). The UNFCCC finance mechanism is accountable to the Conference of the Parties (COP) (UNFCCC, n.d.-d), which is the primary decision-making entity of the UNFCCC (UNDP, n.d.-b). The mechanism comprises various multilateral funds as well as financial mechanisms, which can be seen in Figure 10 (Watson et al., 2024). Relevant to this thesis are two international climate funds, namely the Green Climate Fund (GCF) and the Adaptation Fund (AF), which play an important role in providing financial support for adaptation. The following two subchapters introduce them in more detail.

[7] The non-UNFCCC finance mechanism is not subject to this thesis and therefore not discussed.

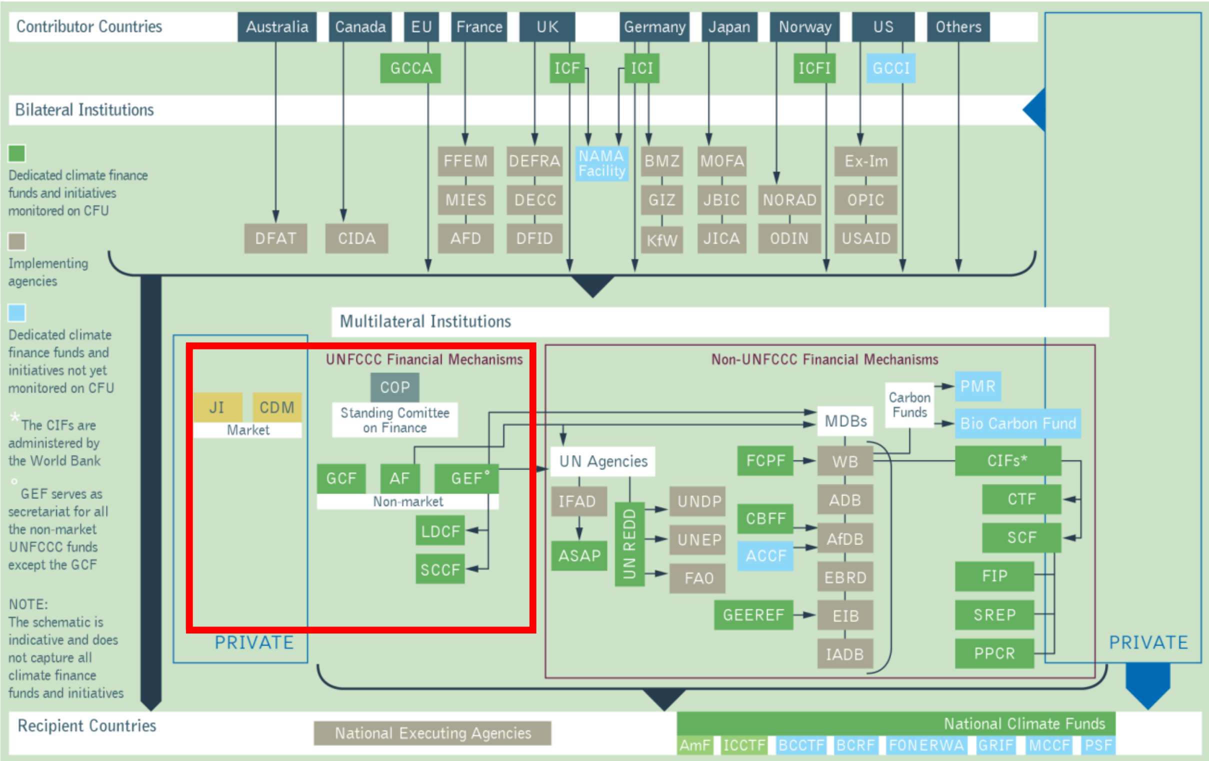

Figure 10: *The architecture of the global climate finance mechanism, with a particular focus on public financing mechanisms. The UNFCCC financial mechanism, the subject of this thesis, is highlighted in red (taken from Watson et al., 2024).*

2.5.3. The Green Climate Fund

General Overview

The Green Climate Fund (GCF) is the largest global fund dedicated to climate change-related issues (GCF, n.d.-a). The main purpose of the GCF is to "(…) support developing countries raise and realize their Nationally Determined Contributions (NDC) ambitions towards low-emissions, climate-resilient pathways" (GCF, n.d.-a). Thereby, the GCF focuses on a country-driven approach which assigns primary responsibility for fund programming and implementation to developing countries (GCF, n.d.-a).

Established in 2010 as a part of the Cancún Agreements, the GCF serves the UNFCCC finance mechanism as well as the Paris Agreement and plays a key role in financing climate projects in developing countries. Since 2015, the year in which the first project was approved (GCF, n.d.-b), the GCF made considerable progress and has invested in 270 projects in 130 countries, worth almost USD 15 billion (GCF, 2024). The GCF investments are generally directed towards four transitions, namely "built environment; energy and industry; human security, livelihoods and wellbeing; and land-use, forests and ecosystems" (GCF, n.d.-a). The fund strives to equally direct financial resources to mitigation (50%) and adaptation (50%) efforts on the basis of grand equivalent. Further, a minimum of 50% of the resources allocated by the GCF for adaptation purposes must be directed towards Small Island Developing States (SIDS), Least Developed Countries (LDC), and African States, which have been identified as being the most vulnerable to climate change (GCF, n.d.-a).

Organization

As already implied, the GCF is part of the UNFCCC finance mechanism (Watson et al., 2024), which is why the policies, eligibility criteria and program priorities are directed by the COP. The GCF is comprised of a number of bodies and entities, each with distinct responsibilities, while also engaging with external stakeholders (Baastel, 2023). Some of the most important components of the GCF organization are listed and briefly explained below.

- The *GCF Board* is the highest decision-making body with a total of 24 members, 50% of which are members from developing countries and 50% from developed countries. The Board is charged with the continuous monitoring of the fund's operations and the provision of annual reports to the COP (Baastel, 2023).
- The *Board Committees* (e.g. Executive Committee, Ethics and Audit Committee, Budget Committee, etc.) support the Board in decision-making within their respective areas of specialization while being accountable to the Board (GCF, n.d.-d).
- The *Secretariat* is a fully independent entity, comprising approximately 220 staff members of various nationalities. The secretariat is accountable to the Board and manages the GCF's daily operations (GCF, n.d.-h).
- The *independent Technical Advisory Panel (iTAP)* has the responsibility of evaluating funding proposals from a technical perspective, and the independent *Accreditation Panel (AP)* provides counsel to the Board on accreditation matters concerning implementing entities and intermediaries (GCF, n.d.-d).
- The *World Bank* is the GCF's trustee (Baastel, 2023).
- The three *Independent Accountability Units* (the Independent Redress Mechanism Unit, the Independent Integrity Unit and the Independent Evaluation Unit) were established to manage risks, to maintain accountability, and to assess the outcomes of GCF projects in order to guarantee that safeguards and international standards are properly applied (GCF, n.d.-c).
- The *National Designated Authorities (NDAs)* are government institutions that act as the link between the fund and each country. They are responsible for a wide range of functions, including strategic supervising of the Fund's activities in a country, as well as verifying that project activities are in line with the country's priorities (GCF, n.d.-g). NDAs play an important role in the project approval process (see below) (GCF, 2017).
- The *Accredited Entities (AEs)* are the channels through which countries access the GCF's financial resources. They are generally responsible for project implementation, management and monitoring. Further, AEs develop project ideas with countries and generate funding proposals for the project approval process (see below). AEs are approved by the GCF and can be either international, national, sub-national or regional, as well as private, public or non-governmental (GCF, n.d.-f).

Project Approval Process

Before programmes and projects are eligible for funding from the GCF, they must pass through a project approval process with various steps (Baastel, 2023; GCF, 2017), which is illustrated in Figure 11. The following simplified explanations regarding this process are based on three sources, two of which are provided by the GCF. In total, there are two project cycles, namely the standard Proposals Approval Process (PAP) and the Simplified Approval Process (SAP), which is only available for projects requiring less than USD 25 million of funding and posing no or minimal risks to the environment (Baastel, 2023). However, this section focuses only on the standard procedure (PAP).

Figure 11: *The approval process of project proposals submitted to the GCF (taken from GCF, 2018b).*

The first major stage in the project approval process is the preparation of the funding proposal (1). This is carried out by the AEs, who work out important details of the project, including the project design and implementation strategies. This funding proposal is subsequently reviewed by NDAs to ensure that the project aligns with the priorities of the respective country. If all requirements are met, a no-objection letter is issued, which is then submitted to the GCF Secretariat together with the funding proposal (3). An alternative two-step process would be for the NDAs and/or the AEs to first develop a concept note (2), following which the final funding proposal will then be generated based on the feedback of the GCF secretariat (Baastel, 2023; GCF, 2017). Although the concept note is considered to be voluntary, the GCF states that "(…) it is highly encouraged for Accredited Entities (AEs) and National Designated Authorities (NDAs) to submit concept notes to reduce review time and lower the transaction costs for all stakeholders [and also because it can] (…) lead to higher "quality of entry" for funding proposals" (GCF, n.d.-e-e).

After submission, the funding proposal is first assessed by the GCF Secretariat, which examines it against the GCF investment criteria and standards. This includes assessing potential negative societal and environmental impacts of the project as well as analysing adherence with financial policies and gender policy. Furthermore, the Secretariat evaluates of how well the project meets activity-specific criteria. Subsequently, the proposal undergoes a technical assessment through the iTAP, again in respect of its activity-specific criteria (4). Those funding proposals that fulfil the necessary requirements according to the Secretariat and the iTAP are transmitted to the GCF Board for consideration at its regular meetings. Ultimately, the Board will determine whether to approve or reject a funding proposal (5) (Baastel, 2023; GCF, 2017). It is possible that the proposal will be conditionally approved, either due to the unavailability of funding or the necessity to modify the project/program design. If the funding proposal is approved, the GCF Secretariat and the AE formulate the legal agreements between the GCF and the AE (6). Once the legal agreements have been signed by the AE and the Executive Director, the Interim Trustee is informed and subsequently drafts a letter of commitment for funding allocation, conditionally on funding availability (GCF, 2017).

2.5.4. The Adaptation Fund

General Overview

The Adaptation Fund (AF) provides financial resources for projects and programmes with an adaptation focus (UNFCCC, n.d.-b) in order to help "(…) developing countries build resilience and adapt to climate change" (AF, n.d.-a). Thereby, the fund follows a country-driven approach, based on the needs and priorities of the recipients (Climate Funds Update, 2019). The AF was originally set up in 2001 under the Kyoto Protocol (UNEP, 2024), but since 1st January 2019, it exclusively serves the Paris Agreement (UNFCCC, n.d.-b).

The AF specifically addresses developing country parties to the Kyoto Protocol which are characterized by a high climate change vulnerability (UNFCCC, n.d.-b), including LDCs, SIDS, and African countries (Climate Funds Update, 2019). AF investments target different sectors, such as agriculture, water management, rural development, disaster risk reduction, or disaster risk reduction and early warning systems. If a project addresses several sectors at the same time, it is classified as a "multisector project" (AF, n.d.-f). Since the approval of the first two projects in 2010 (AF, n.d.-h), over USD 1.2 billion were allocated to projects and programs addressing climate change adaptation and resilience, encompassing over 175 specific, localized projects targeting highly vulnerable communities in developing countries, benefiting more than 43 million individuals (Pueschel, 2024).

The funding of the AF is intrinsically tied to carbon trading and emission reduction mechanisms under the Kyoto Protocol. Thus, a significant part of the AF funding comes from a 2% share of the proceeds from the sale of Certified Emission Reductions (CERs). CERs are generated through the Clean Development Mechanism (CDM) which was established under the Kyoto Protocol (see also Figure 10 in Chapter 2.5.2.) (UNFCCC, n.d.-b). However, there are also other sources of funding, including voluntary contributions from governments, the private sector or individuals (AF, n.d.-d).

Organization

As with the GCF, the AF is structured around units and entities (AF, n.d.-a), some of which are briefly described in the following sections:

- The *Adaptation Fund Board (AFB)* is the decision-making authority of the AF which comprises 16 members along with 16 alternates, each standing for a Kyoto Protocol Party. Approximately 69% of all members are representatives of developing countries (AF, n.d.-c). Among other responsibilities, the AFB is in charge of the strategic monitoring of programmes and projects funded by the AF (AF, 2022a).
- The *Adaptation Fund Board Secretariat (AFBS)* offers various services to the AFB, including advising, researching and administering (AF, n.d.-g).
- As with the GCF, the *World Bank* is the interim trustee of the AF. It is responsible for selling the CERs as well as for managing the AF trust fund, in which the money of the AF is stored before it is allocated among projects and programs according to the AFBs instructions (AF, n.d.-i). It is worth mentioning that the World Bank is not only the Fund's trustee, but also an accredited Implementing Entity (MIE) that implements projects and programmes and has the right to access AF funding (see below) (AF, n.d.-h).
- The accredited *Implementing Entities* can either be national (National Implementing Entities (NIEs)), regional (Regional Implementing Entities (RIEs)), or multilateral institutions (Multilateral Implementing Entities (MIEs)). These institutions are accredited by the AFB and are able to directly access funding for projects and programs (AF, n.d.-e).

- The *Accreditation Panel* comprises two AFB members and three independent experts. Its role is to verify that recipient organizations of financial resources adhere to fiduciary standards. The Accreditation Panel therefore makes recommendations with regard to the accreditation of implementing entities (AF, n.d.-b).
- The *Project and Program Review Committee (PPRC)* supports the AFB in reviewing projects and programs with regard to the Operational Policies and Guidelines (OPG) for Parties to receive funding and has an advisory function in this respect (AF, 2015).

Project Approval Process

The project approval process of the AF is explained on the basis of the official document addressing policies and guidelines relevant for accessing the fund's financial resources. The process can be either a one-step or a two-step process. Small-size projects with budgets of up to USD 1 million usually adhere to a one-step approval process. In contrast, regular projects/programmes with budgets exceeding million 1 USD, are subject to either a one-step or a two-step approval process (AF, 2022a).

<u>One-step process:</u> Firstly, a project proposal is directly transmitted to the AFBS by eligible Parties to the Kyoto Protocol (developing countries) through implementing entities. The proposal provides detailed information about the project/programme, including a description of its objectives, components, and outcomes. Subsequently, the AFBS assesses the proposal with regard to its consistency and formulates a technical review addressing various criteria. These include, for example, the country eligibility (e.g. whether the country is a Party to the Kyoto Protocol), or the project eligibility (e.g. whether the project is cost effective). In the next stage of the process, the proposal and the technical review are transmitted to the PPRC, which carries out a further evaluation. Finally, the AFB assesses the PPRC recommendations and decides on the approval of the project funding. In the event of a rejection, the proposal can be resubmitted after improvement (AF, 2022a).

<u>Two-step process:</u> The procedure described above for the one-step process is also carried out in the two-step process. However, the two-step process also encompasses the development and subsequent approval of a brief project concept before the final project proposal is formulated (AF, 2022a).

After the proposal has been approved, the AFBS prepares contracts and other required agreements with implementing entities. These documents will be provided for signing to the Chair of the AFB or another Member authorised to do so. Finally, the funding is allocated through the Trustee, based on written guidelines provided by the Board, which must be signed by the Chair or another designated Board Member. The Trustee will also inform the Board about the distribution of the funds (AF, 2022a).

3. Methodology

As mentioned in the Introduction, the main objective of this thesis was to determine whether adaptation funding is being allocated efficiently in the sense that it addresses the climate-related hazards that cause the most fatalities. This required two basic investigations: first, an analysis of the number of fatalities caused by the hazard types under consideration, and second, an analysis of the distribution of adaptation funding for projects targeting the same hazards. The detailed methodological approach is explained in the following subchapters and illustrated in Figure 12.

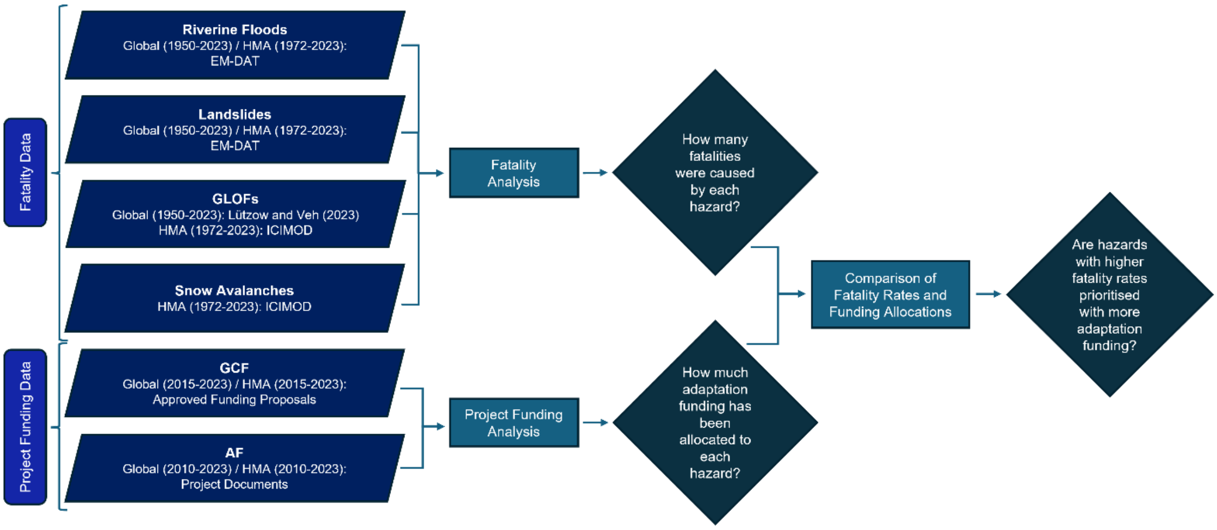

Figure 12: *Workflow diagram representing the procedures of the study (own illustration).*

3.1. General Methodological Considerations

The first step was to define the general scope of the investigations mentioned above. In terms of hazard types, it was decided to place the focus on riverine floods, landslides, GLOFs and snow avalanches, as these are highly impactful hazards with significant consequences, which is indicated by various sources (e.g. Jonkman et al., 2024; Lacasse et al., 2010; Rinzin et al., 2023; Schweizer et al., 2021). Other important slow-onset hazards (e.g. droughts), were not analysed because it is much more difficult to determine exactly how many people died as a direct result of these types of hazards. Regarding the source of funding for adaptation projects, the decision was made to analyse the financing provided by two major funds of the UNFCCC climate finance mechanism, namely the GCF and the AF. As already implied in subchapters 2.5.3. and 2.5.4., these funds are particularly important in the climate finance mechanism, as they distribute significant amounts of funding and thus play a crucial role in assisting developing countries to meet their adaptation needs. In addition, the data of these two funds are easily accessible to the public, facilitating research.

Generally, all investigations of this Master's thesis were carried out on two different levels. One part of the analyses was conducted at the global level, whereby it was decided that only non-Annex I Parties to the UNFCCC would be studied. These are mainly developing countries, which are particularly vulnerable to climate change impacts (UNFCCC, n.d.-f), and are therefore in special need for effective CCA and DRR. This choice also allowed a comparison between the number of fatalities and the funding amounts of GCF projects, as the GCF focuses exclusively on non-Annex I countries. Although the AF addresses countries that have signed the Kyoto Protocol, it was decided to make no distinction and to investigate only non-Annex I Parties, as these two groups are almost identical. The second part of the analyses specifically focused on the countries of HMA, which is defined as the region that "(…) extends from the Himalayas in the south and east to the Hindu Kush in the west and to Tien Shan in the north, including also the Karakoram, the Pamir-Alay and the Kunlun mountain ranges" (Lalande et al., 2021, p. 1062). Based on this definition, data was compiled for Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Tajikistan, and Uzbekistan (see Figure 13). In addition, Bangladesh has also been added as a country because the impacts of disasters that occur in the high mountain areas of Asia can extend to downstream regions, with Bangladesh being particularly affected. Generally, there are many reasons for analysing HMA in the context of this Master's thesis. As a particularly large and diverse mountain region, HMA is of critical importance, including for delivering ecosystem services (e.g. fresh water provision) to millions of people (Miles et al., 2021), a substantial portion of whom live in developing countries. However, the specific geographical conditions of HMA, characterized by the largest snow, permafrost and glacier coverage beyond the polar regions (Acharya et al., 2023), combined with its monsoon-influenced climate (Lalande et al., 2021), make it a hotspot for different types of hazards that can lead to disasters affecting the vulnerable population. The effectiveness of CCA and DRR in this region is therefore crucial, not only to protect people but also to ensure sustainable development.

Figure 13: *The countries with territories in HMA (Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Tajikistan, Uzbekistan) and Bangladesh analysed in the context of this thesis (basemap: Natural Earth, n.d.; country borders: OpenDataSoft, 2019).*

3.2. Analysis of Fatalities from Climate-Related Disasters

3.2.1. Data Collection

Once this general scope for the thesis had been established, the first part of the study, the analysis of fatalities, could be carried out. For the global analysis, fatalities from three out of the four climate-related hazards listed above were examined, namely riverine floods, landslides, and GLOFs. Thus, in the course of this research it was found that the availability of fatality data from snow avalanches is generally very limited, particularly on a global scale. For riverine floods and landslides, data were taken from the publicly available international disaster database EM-DAT, which has data going back to 1900, but is limited in its representativeness before 2000 (see CRED, 2023b). This database is often used as a basis for various scientific studies (e.g. CRED & UNDRR, 2020; Hamidifar & Nones, 2023) and is known for its considerable amount of data on different types of natural disasters. The sources of EM-DAT data typically includes non-governmental organizations (NGOs), research institutes, UN agencies, press agencies, and reinsurance companies (CRED, 2023a). For GLOFs, however, EM-DAT has recorded very few disasters and is therefore not suitable for such an analysis. Generally, finding accurate fatality data on GLOFs is challenging as the reporting of GLOFs varies greatly across countries and regions, lacking standardized procedures (Lützow et al., 2023). In the end, it was decided to work with a global GLOF database, recently published by Lützow et al. (2023), which goes back to the 9th century and is based on internet and literature sources (see Lützow & Veh, 2023).

For HMA, fatalities from all four climate-related hazards were analysed. Data for riverine floods and landslides were again obtained from EM-DAT for the entire HMA countries, while data for snow avalanches and GLOFs were taken specifically for the HMA region from the International Centre for Integrated Mountain Development (ICIMOD). In the case of snow avalanches, data was used from a database published by Steiner and Acharya (2023), which goes back to 1972 and originates from various sources, including newspapers, technical reports, scientific literature and social media (Acharya et al., 2023). With regard to GLOFs, the fatality data was retrieved from a database published by Steiner and Shrestha (2023), which constitutes "(…) the first comprehensive inventory of GLOFs in HMA (…)" (Shrestha et al., 2023, p. 3941). The data go back to the 16th century and were compiled from scientific literature, regional media reports, local knowledge and other sources (Shrestha et al., 2023).

In terms of the investigation period of the number of fatalities, different approaches were taken at the global level and the HMA level. Thus, the global fatalities from all three hazards were analysed over the period 1950-2023, partly to maintain representativeness and partly because climate change has intensified significantly since 1950 (see Theoretical Background). However, with regard to the HMA analysis, it was decided to focus the fatality analysis on the period 1972-2023 due to the fact that the fatality data on snow avalanches does not go back further in time.

3.2.2. Data Preparation

For both the global and the HMA analyses, the fatality data was first downloaded as an Excel file and then filtered by year (1950-2023 for the global analysis and 1972-2023 for the HMA analysis) and by country (non-Annex I countries for the global analysis and countries in HMA for the HMA analysis). All databases report the number of fatalities per event. However, in both GLOF databases, there were some events for which no absolute number of fatalities was provided. In the case of the global database, there were 11 of these events between 1950 and 2023. Since absolute numbers were required for the analysis, numbers were assigned to these events based on the disaster impact description provided in the Excel file, which is shown in Table 1 below.

Table 1: *The number of fatalities assigned to 7 of the 11 GLOF events for which no absolute number of fatalities was recorded in the global database.*

GLOF Event (Country / Year)	Disaster Impact Description	Assigned Number of Fatalities
India / 1971	"13-16 fatalities"	13
Kazakhstan / 1973	"dozens of people died"	50
China / 1988	"killed several people"	5
Kyrgyzstan / 1998	"caused death of >100 residents"	100
India / 2013	"caused death of ~ 6,000 people"	6,000
China / 2013	"killed several people"	5
Peru / 2020	"at least 13 fatalities"	13

For the remaining four GLOF events, for which absolute fatality data were not available, the disaster impact was described in the Excel file as follows: "loss of human lives", "there were victims" or "human casualties". Since one of these events was also recorded in the other GLOF database used for HMA, the number of fatalities registered there was used for the global analysis (Kazakhstan, 1963 with 53 fatalities). For the other three events, specific research was conducted to determine the absolute number of fatalities. In one case (Kazakhstan, 1956), no precise information could be found, which is why 10 fatalities were assigned as a placeholder but without any scientific basis. However, absolute numbers could be determined for the other two events (see Table 2).

Table 2: *The two GLOF events for which the absolute number of fatalities was determined by research.*

GLOF Event (Country / Year)	Assigned Number of Fatalities	Source
Nepal / 1977	2	"An earlier GLOF in 1977 was recorded in Dudh Koshi. This event killed two or three people (…)" (Agrawala et al., 2003, p. 29)
Nepal / 1998	2	"Tam Pokhari (Sabai Tsho) is situated at the tongue of the Sha (Sabai) Glacier in the headwater of the Inkhu Khola of the Dudh Koshi Sub-basin. It burst on 3 September 1998. Two persons were killed (…)" (Mool et al., 2001, p. 135).

As mentioned above, there were also events in the GLOF database for HMA for which no absolute number of fatalities was recorded in the Excel file (marked with "+" under "Lives_total"), namely Kazakhstan (1977), Nepal (1988) and China (2013). As the event in China was recorded in the global database, the same number of fatalities as was recorded there was entered in the HMA database (5 fatalities) (see Table 1). For the other two events, no more precise information could be obtained through research, which is why 20 fatalities were added as placeholder for each event, again without any scientific basis.

3.2.3. Data Analysis

Once the absolute number of fatalities was determined for all events, the number of fatalities per year was calculated for each hazard in the global and HMA datasets. This was then used to perform various statistical analyses (descriptive statistics) in Excel. The purpose of this was to give a general overview of the data and to determine which type of hazard was the deadliest, both globally for non-Annex I countries and for countries in HMA. In this context, various statistical measures were calculated (i.e. measures of central tendency, measures of position and measures of dispersion) and then visualized as boxplots. The nature of the data was further illustrated using histograms, scatterplots and line graphs. An additional analysis was carried out to determine the number of people killed per month by each climate-related hazard. At the global level, a distinction was made between non-Annex I countries in the Northern Hemisphere and Southern Hemisphere. The results were presented as bar charts.

Both at the global level and for HMA, the data was also analysed in more detail at the regional level (global analysis) and at the country level (HMA analysis). For the global analysis, the non-Annex I countries were grouped into different regions based on the regional groupings of the GCF and AF (Africa, Asia-Pacific, Eastern Europe, Latin America and the Pacific), which ultimately allows for comparability between fatality data and project funding data. Based on this regional grouping, the number of fatalities per million inhabitants was calculated for each region and presented as a column chart. A similar analysis was carried out for HMA, but at country level. The purpose of these analyses was to provide a more detailed overview of the fatality data by illustrating regional differences.

3.3. Project Funding Analysis

3.3.1. Data Collection and Preparation

Following the fatality analysis, the allocation of adaptation funding provided by the GCF and the AF for projects aimed at reducing fatalities caused by the aforementioned hazards was examined. For both funds, all projects were analysed between the first project funding, which was in 2015 for the GCF and in 2010 for the AF, and the end of 2023.

The basis for the project funding investigation consisted of Excel files retrieved from the GCF's online data library and the official AF website. These Excel documents contain general information on all projects financed since the opening of the two funds. This includes, for example, the title of the project, the target countries, the entities involved and the amounts of funding invested in the project. The first step was to filter projects according to their general focus (i.e. adaptation and mitigation). In the case of the GCF, this meant that all adaptation projects and cross-cutting projects (i.e. projects covering both adaptation and mitigation aspects) were extracted. For the AF, which is only dedicated to adaptation, projects could be filtered directly by DRR. Therefore, projects falling into the categories "Disaster Risk Reduction", "Disaster Risk Reduction and Early Warning Systems", and "Multi-sectoral", which may also include disaster risk reduction activities, were filtered out.

After this initial project review, a total of 177 GCF projects and 41 AF projects remained for further examination. The next step was to analyse these projects in more detail to determine whether they were focused on reducing fatalities from riverine floods, landslides, snow avalanches or GLOFs. This step was particularly important for GCF projects, as these could not be directly filtered by DRR (see above). However, it was also necessary for AF projects to ensure that DRR projects were not designed solely to minimize economic damage. It should be noted that projects with measures that could theoretically contribute to reducing fatalities but were not specifically designed to do so were excluded (e.g. projects focusing on the implementation of early warning systems that are not installed to enable people to be evacuated but are used in an agricultural context).

To carry out this detailed analysis, the "Approved Funding Proposal" of each GCF project and the "Project Document" of each AF project, both available online in pdf format on the websites of the two funds, were reviewed. These documents, which can be more than 200 pages long, contain detailed information about each project, including the context, in which the project is embedded, its objectives and approaches, as well as descriptions of the hazards it is targeting. It is important to note that not all documents were read in full, as this would have gone beyond the timeframe available for this thesis. Instead, with the additional support of the keyword search function available for pdf documents, the textual analysis focused mainly on specific chapters and sections, including the general description of the project, its outcomes, outputs, and activities, as well as the description of the project's impact potential. However, the textual analysis varied in some cases, as not every document contained the necessary information in the same passages.

After reviewing all documents, those projects that met the aforementioned criteria were categorized as "usable" in the Excel spreadsheet. In this respect, the GCF had a total of 33 "usable" projects, while the AF had 19. For these projects, some additional information was recorded. For example, it was noted whether they had DRR (i.e. reducing fatalities) as a main or a minor focus. In the context of this thesis, "main focus" means that the primary objective of the overall project is to save lives from the direct impacts of climate-related disasters. "Minor focus", on the other hand, refers to projects that have a different primary focus (e.g. climate-resilient agriculture or water management), but still include individual activities explicitly designed to reduce fatalities. In addition, the start date of each usable project was also recorded which would be used to add a temporal component to the analysis (see chapter 3.4.). For the GCF projects, this information was obtained from the official website. Thereby, the first date in the project timeline was recorded, which in most cases was the date on which the concept note was received. If this step was not listed, the date when the funding proposal was received was used instead. In the case of the AF, data was available concerning the date of project approval, which was already included in the Excel file.

3.3.2. Data Analysis

Once the data was prepared, the amount of GCF and AF funding could be analysed in Excel both at the global level for non-Annex I countries and for HMA countries. To provide a general overview, the amount of funding was determined according to the climate-related hazard type or combination of hazard types addressed by the projects. Since only individual climate-related hazard types are relevant for answering the research question of this thesis, the same analysis was also carried out for each type of climate-related hazard separately. Thus, for projects dealing with more than one climate-related hazard, the funding was allocated to both hazards (i.e. for a USD 5 million project addressing both riverine floods and landslides simultaneously, USD 5 million was allocated to riverine floods and the same amount to landslides). A further analysis focused on whether GCF projects have a main or a minor focus on DRR (see above), depending on which climate-related hazard type they address. The purpose of this analysis was to determine whether the volume of funding attributed to a specific hazard tends to be over- or underestimated, which is important for interpreting the comparison of fatalities and funding amounts. Additionally, the amount of funding per hazard type was examined at both the regional level, using the same regions as in the fatality analysis (global analysis), and the country level (HMA analysis) to show regional differences. All results were presented in tables, bar diagrams and pie charts.

3.4. Comparison of Fatalities and Project Funding

The final analysis consisted of comparing the results of the fatality analysis and the project funding analysis to determine whether the climate-related hazards that caused the most fatalities were also addressed by high levels of funding from the GCF and AF. This was also done in Excel by calculating the amount of funding per fatality for each hazard both globally for non-Annex I countries and for HMA countries. This normalized approach provides an understanding of how resources should be allocated relative to the impact of each hazard. The results were presented as bar charts. Again, it was decided to also show regional differences to provide a more comprehensive picture. As part of the global analysis, the amount of funding per fatality was determined for each region (Africa, Asia-Pacific, Eastern Europe, Latin America and the Caribbean) and then illustrated as bar charts. For the HMA analysis, the same approach was followed. However, it was decided to additionally plot the correlation between the amount of funding and the number of fatalities per million inhabitants for each climate-related hazard in each country.

A further analysis, carried out at both the global level and the HMA level, examined the temporal pattern of fatalities in relation to the temporal pattern of funding for each climate-related hazard. In view of answering the main research question of this thesis, the aim of this was to provide insight into whether, for example, a particularly high number of fatalities from riverine floods in a given year triggered a particularly high level of funding for riverine flood projects. The results of this analysis were visualised as line graphs.

4. Results

This chapter presents the findings of the analyses described in the Methodology, illustrated with graphs and tables. It is structured into two subchapters, the first focusing on the global level (i.e. non-Annex I countries) and the second on HMA countries. Each subchapter begins with the outcomes of the fatality analysis, followed by an overview of the results of the study on project funding allocations, and concludes with the comparison of the number of fatalities and the amount of project funding. The raw data on which the results are based can be found in Appendix A.

4.1. Global Analysis (Non-Annex I Countries)

4.1.1. Analysis of Fatalities Caused by Climate-Related Hazards

In this subchapter, the results of the fatality analysis for non-Annex I countries are presented, which covers the period from 1950 to 2023. Table 3 shows the statistical measures (i.e. measures of central tendency, measures of position, and measures of dispersion), calculated on the basis of the annual number of fatalities caused by riverine floods, landslides, and GLOFs.

Table 3: *Statistical measures calculated for the annual number of fatalities from riverine floods, landslides and GLOFs in non-Annex I countries for the period 1950-2023.*

		Riverine Floods	Landslides	GLOFs
Measures of Central Tendency	**Mean**	1,681.38	502.58	124.61
	Median	423	336.5	0
	Mode	0	0	0
Measures of Position	**1st Quartile**	0	174.25	0
	2nd Quartile (Median)	423	336.5	0
	3rd Quartile	2,908.5	617.5	0
Measures of Dispersion	**IQR**	2,908.5	443.25	0
	Range	9,498	3,541	6,005
	Maximum	9,498	3,541	6,005
	Minimum	0	0	0
	Variance	4,979,800.43	372,862.27	539,276.65
	Standard Deviation	2,216.42	606.48	729.38

Some of the results of the statistical measures are visualised in the form of boxplots, as illustrated in Figure 14. The lower limit of the box represents the 1st quartile (i.e. the value below which 25% of the fatality data falls), the centre line in the box shows the median, which is equal to the 2nd quartile (i.e. the value below which 50% of the fatality data falls), and the upper limit of the box illustrates the 3rd quartile (i.e. the value below which 75% of the fatality data falls). The width of the whole box visualizes the Interquartile Range (IQR), which is the middle 50% spread of the fatality data.

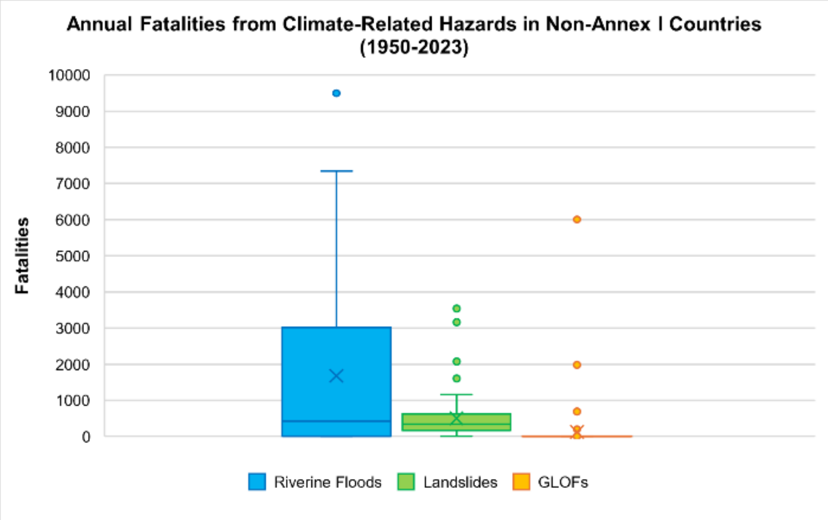

Figure 14: *Boxplots for the annual number of fatalities from climate-related hazards in non-Annex I countries between 1950 and 2023.*

The boxplots above show that the median annual number of fatalities from riverine floods and landslides are very close to each other, which is also evident from Table 3. However, when analysing the mean, large differences become apparent, not only when comparing riverine floods and landslides, but also when considering GLOFs. For riverine floods, due to the relatively low median, it can be concluded from the large size of the mean that there are years with a particularly high number of fatalities. This results in a large dispersion of the data, which is illustrated by the variance and standard deviation, as well as the width of the box (IQR) for riverine floods, which is significantly greater than for landslides and GLOFs. Another striking feature is that the mean and the median are smallest for GLOFs, indicating that in many years no or only few people died due to this hazard. This is also supported by the fact that the very small (i.e. compressed) box of the boxplot for GLOFs is located at very low fatality rates. Furthermore, it also has to be mentioned that for all three climate-related hazards, the mode, which is the most common value in the data set, is zero, meaning that in most years all three hazards caused no fatalities.

Another characteristic feature of the boxplots are the vertical lines extending from the top and bottom of the boxes (whiskers, i.e. the fatality data range within 1.5 times the IQR) and the individual points that lie above and below the boxes (outliers, i.e. fatality data points falling beyond the whiskers). In addition to the previously calculated measures of dispersion, this provides further insight into the scatter of the fatality data. The boxplot for riverine floods, in particular, has a very long upper whisker, reaffirming that there are years with exceptionally high fatality rates. The upper whisker of the landslide boxplot, however, is shorter, indicating a more constant number of fatalities each year, with fewer extreme values compared to riverine floods. In contrast to both riverine floods and GLOFs, it is noteworthy that the landslide data also displays a lower whisker, suggesting fewer years with particularly low fatality numbers compared to the other two hazards. Looking at the boxplot for GLOFs, the upper whisker is extremely short, again suggesting that most annual fatalities are clustered around zero since the box is at very low fatality rates, as already mentioned above.

When analysing the outliers, the GLOF boxplot has the most (i.e. 12), indicating occasional years with significantly higher numbers of fatalities. This, however, becomes only apparent when the y-axis is adjusted accordingly. It is striking that both GLOFs as well as riverine floods have one exceptionally high outlier which represents 2013, a year characterized by a particularly high number of fatalities. Looking at the landslide boxplot, none of its four outliers are located at such a high level of fatalities.

It is worth noting, that the highest outlier in the riverine flood and GLOF boxplots (i.e. 2013) is significantly influenced by a disaster that occurred in India. Of the 9,597 people who died due to riverine floods in 2013, 6,054 fatalities are attributed to this particular disaster. In the case of GLOFs, 6,000 fatalities are associated with this event, out of a total of 6,005 fatalities in 2013. This outlier in the GLOF database clearly influences the previously calculated statistical measures. If the 2013 event in India is not taken into account, the mean annual number of fatalities falls from 124.61 to 43.53. Additionally, the measures of dispersion also have significantly lower values when this disaster is excluded. The variance is reduced from 539,276.65 to 59,123.376 and the standard deviation from 729.38 to 241.5.

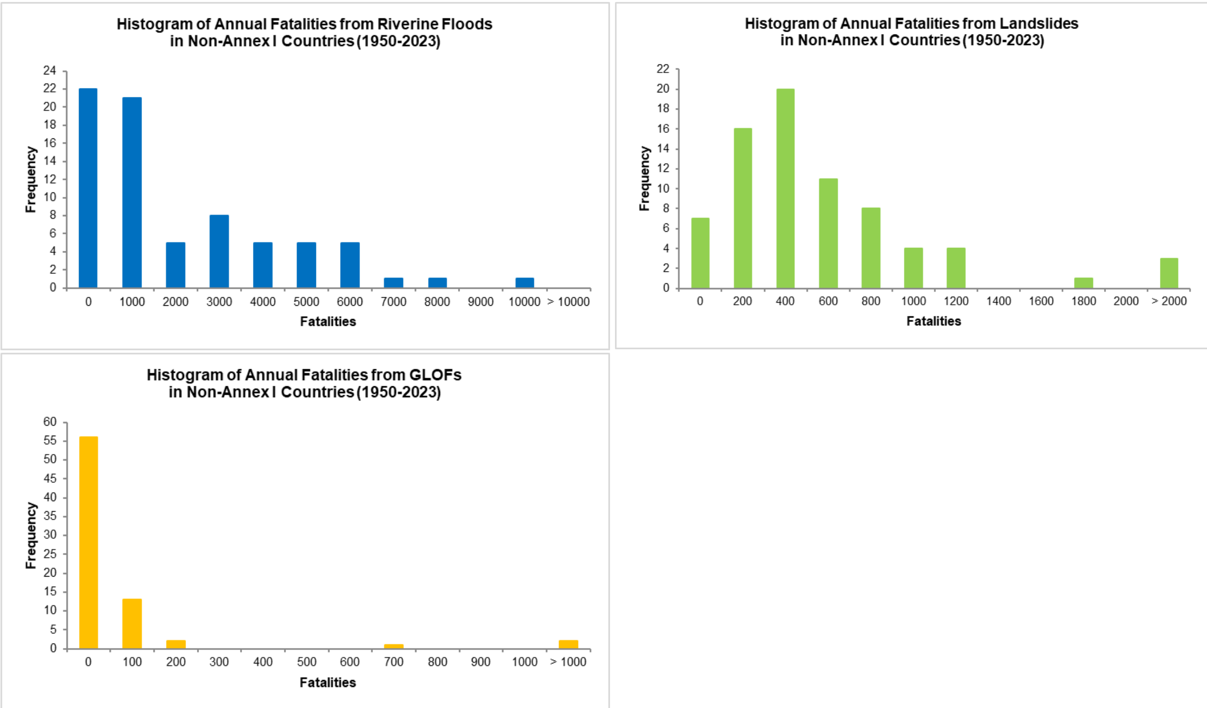

Figure 15: *Histograms for the annual number of fatalities from riverine floods (blue), landslides (green) and GLOFs (yellow) in non-Annex I countries between 1950 and 2023.*

The histograms in Figure 15 show the number of years (see y-axis) that fall within a particular category of fatalities from the three climate-related hazards (e.g. 1 to 1,000 fatalities, 1,001 to 2,000 fatalities, etc.) (see x-axis). It should be noted that a separate category has been created for years with zero fatalities, as this category is very dominant. In terms of riverine floods, the histogram supports the previous findings, namely that the annual number of fatalities shows a significant spread and that there are years with particularly high fatality rates. Furthermore, annual fatalities from landslides are again relatively constant, but generally lower than from riverine floods. GLOFs caused the lowest annual number of fatalities, highlighted by the particularly high number of years with zero fatalities, and also by the fact that the fatality categories generally have relatively low numbers (see x-axis).

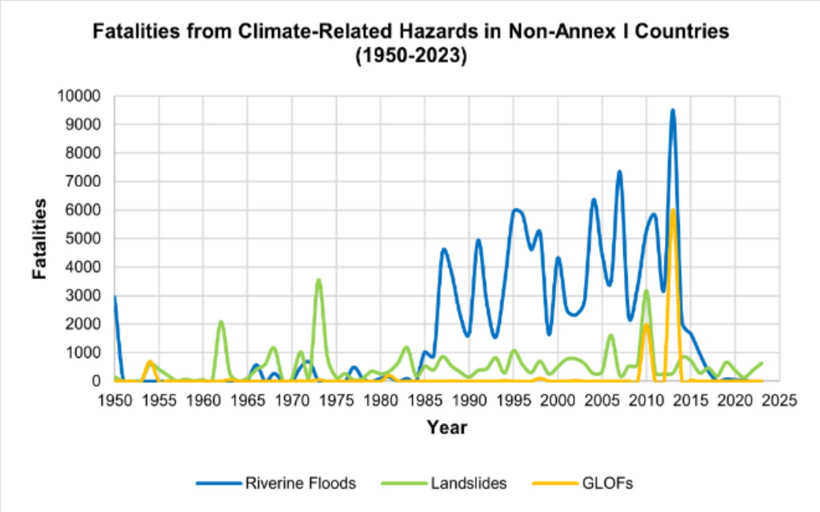

Figure 16: *Direct comparison of the annual number of fatalities from riverine floods (blue), landslides (green) and GLOFs (yellow) in non-Annex I countries between 1950 and 2023.*

Figure 16 shows the annual number of fatalities caused by the three climate-related hazards in direct comparison as a line graph. The results confirm that riverine floods cause the most fatalities, followed by landslides and GLOFs. In addition, the consistency of fatalities due to landslides is also evident here. It is noticeable that the number of fatalities due to riverine floods increased considerably from the mid-1980s onwards, but has fallen sharply since around 2011 (with the exception of 2013). However, there is no such clear pattern for landslides and GLOFs. Another striking feature is that 2013 again stands out clearly in the graphs for both riverine floods and GLOFs due to the major disaster in India (see outliers in the boxplots of Figure 14).

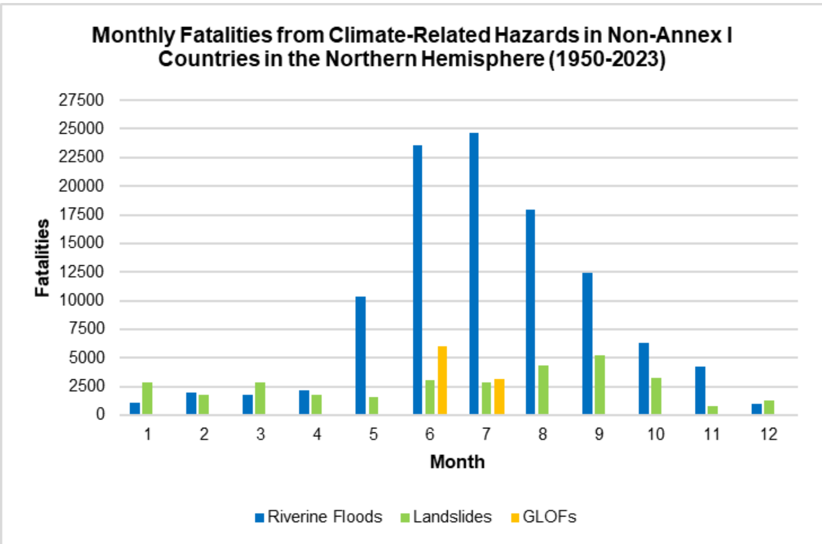

Figure 17: *Monthly fatalities from climate-related hazards in non-Annex I countries in the Northern Hemisphere.*

In Figure 17, which illustrates the monthly number of fatalities from climate-related hazards in non-Annex I countries between 1950 and 2023 on the Northern Hemisphere, it is visible that riverine floods caused fatalities every month, especially between May and September. This can be partly attributed to snowmelt in mountainous areas, which peaks at this time of the year and leads to increased river flows. Also noteworthy in this regard are tropical cyclones and the monsoon season, which affect certain regions of the Northern Hemisphere and cause heavy rainfall and flooding. Looking at the fatalities from landslides, they are relatively evenly distributed throughout the year, but slightly higher in August and September. However, there are no such clear fluctuations as for riverine floods. This may be due to the fact that landslides are a more diverse hazard than riverine floods, encompassing different types (e.g. debris flows or rock falls), which are driven by various processes and factors, including non-climatic ones that do not depend on seasonal patterns (see chapter 2.2.2.). In terms of GLOF fatalities, they are concentrated in the months of June and July, but there are also comparably low numbers of fatalities in August (i.e. 33 fatalities), September (i.e. 4 fatalities), and October (i.e. 21 fatalities), which are not visible on the plot. It should be noted that all the fatalities in June were due to the aforementioned GLOF event that occurred in India in 2013. However, the fatalities recorded in July were the result of several disasters. The fact that GLOF fatalities tend to be concentrated in the summer months of the Northern Hemisphere may be partly related to higher temperatures, which weaken snow and ice, leading to an increased number of ice avalanches that can hit glacial lakes. In addition, increased glacier melt in summer due to higher temperatures can increase the volume of water in glacial lakes. The influence of heavy monsoon rains at this time of the year is also worth noting, as this can also contribute to triggering GLOFs, for example by further increasing the water volume of glacial lakes or by triggering landslides that can impact glacial lakes.

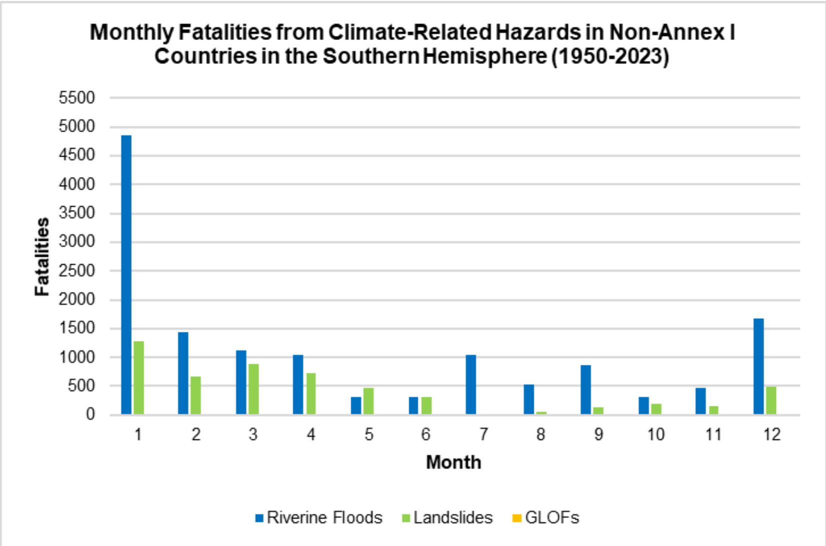

Figure 18: *Monthly fatalities from climate-related hazards in non-Annex I countries in the Southern Hemisphere.*

Figure 18 presents the results of the same analysis as in Figure 17, but this time for non-Annex I countries in the Southern Hemisphere. It shows that fatalities from riverine floods are more evenly distributed over the year than in the Northern Hemisphere. However, there are slightly more fatalities between December and February, which may be related to this period coinciding with the rainy season in some regions of the Southern Hemisphere and the tropical cyclone season, similar to the June, July, and August in the Northern Hemisphere. Also analogous to the summer months in the Northern Hemisphere, the Southern Hemisphere experiences increased snow and ice melt rates during December, January, and February due to higher temperatures, which can contribute to riverine floods. Fatalities from landslides are again relatively uniformly spread throughout the year, but less so than in the Northern Hemisphere. There is a slight increase in the number of fatalities from December to April, which, as explained above, overlaps with the period of heavy rainfall, which can lead to increased slope destabilisation and hence landslides. In the case of GLOFs, there are only 13 fatalities in February, but again they are not apparent on the plot. These fatalities resulted from a single event in Peru in 2020. It is therefore not possible to identify any seasonality in GLOF fatalities in the Southern Hemisphere.

Regional Analysis

The following tables and figures describe the results of the regional fatality analysis, also covering the period 1950-2023, with the non-Annex I countries grouped into the regions of Africa, Asia-Pacific, Eastern Europe, and Latin America and the Caribbean. Table 4 and Figure 19 below illustrate the regional variations in the annual number of fatalities by region and by type of hazard, focusing on absolute number of fatalities and the number of fatalities per million inhabitants.

Table 4: *Total number of fatalities from riverine floods, landslides and GLOFs in non-Annex I countries between 1950 and 2023, by region.*

	Total Number of Fatalities		
Region	**Riverine Floods**	**Landslides**	**GLOFs**
Africa	17,022	2,251	0
Asia-Pacific	93,787	20,0008	9,208
Eastern-Europe	156	24	0
Latin America and the Caribbean	13,457	14,908	13

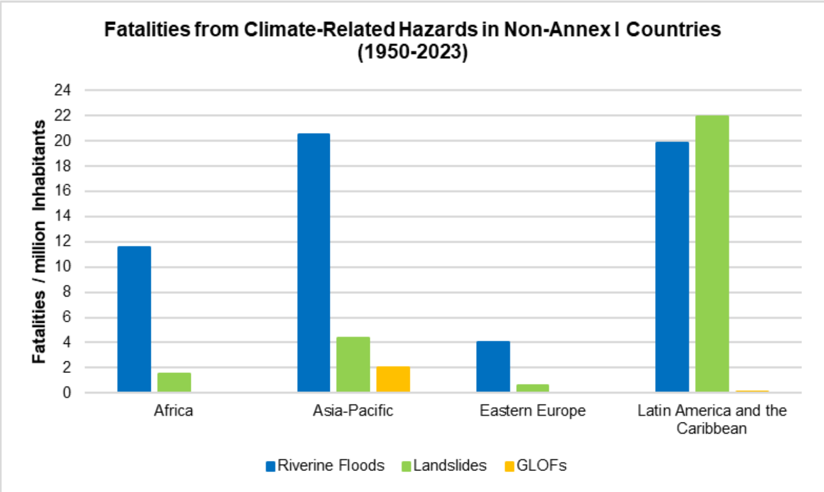

Figure 19: *Annual number of fatalities per million inhabitants from climate-related hazards in non-Annex I countries between 1950 and 2023, by region.*

As can be seen from Table 4, which presents the total number of fatalities caused by each type of hazard, the Asia-Pacific and Latin America and the Caribbean regions generally experienced the highest fatality rates, followed by Africa and Eastern Europe. When considering the number of fatalities per million inhabitants in dependence on the type of hazard (see Figure 19), the bar charts show that in three out of four regions, the pattern is similar to that observed at the global level, with riverine floods causing the most fatalities per million inhabitants, followed by landslides and GLOFs. The exception is Latin America and the Caribbean, where landslides resulted in slightly more fatalities than riverine floods. Additionally, it can be noted that GLOF fatalities were only reported in two regions, namely Asia-Pacific and Latin America and the Caribbean.

Regarding the observation that landslides caused such a high number of fatalities in Latin America and the Caribbean, while the figure is relatively low in the Asia-Pacific region, it should be mentioned that, according to EM-DAT, of the total of 14,908 fatalities caused by landslides in Latin America and the Caribbean, two disasters were responsible for a substantial proportion of these deaths. One of these disasters occurred in Honduras in 1973, killing 2,800 people, and the other in Peru in 1962, resulting in 2,000 fatalities. However, it is also important to note that the Asia-Pacific region is more characterised by islands and countries with flat or low-lying terrain, where a significant proportion of the people lives. In Latin America, on the other hand, more people live in hilly and mountainous areas, where they are more exposed to landslides.

Table 5: Total number of fatalities from riverine floods, landslides and GLOFs in Latin America and the Caribbean between 1950 and 2023, by sub-region.

	Total Number of Fatalities		
Sub-Region	**Riverine Floods**	**Landslides**	**GLOFs**
South America (Andean Countries)	4,951	9,491	13
South America (Non-Andean Countries)	3,283	1,269	0
Central America	1,292	3,886	0
Caribbean	3,931	262	0

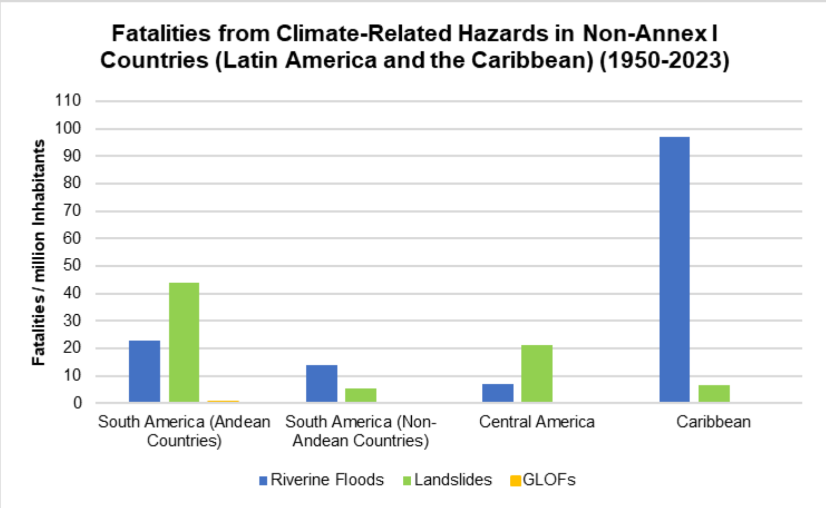

Figure 20: Number of fatalities per million inhabitants from climate-related hazards in non-Annex I countries in Latin America and the Caribbean between 1950 and 2023, by sub-region.

Table 5 and Figure 20 provide a more detailed look at the number of fatalities (per million inhabitants) in the sub-regions of Latin America and the Caribbean. This illustrates that some of the regions discussed above are very diverse, leading to large differences in the number of fatalities from climate-related hazards within individual regions. A similar analysis was also carried out specifically for the Asia-Pacific sub-regions, the results of which can be found in Appendix B.

The results shown above indicate that landslides have been the leading cause of fatalities in countries shaped by the Andes and in Central America, which includes Mexico. This reflects the fact that these regions have a mountainous and hilly geography, making them prone to landslides. Non-Andean countries and the Caribbean recorded higher fatality rates per million inhabitants due to riverine floods. In the Caribbean in particular, riverine floods have caused a significant number of fatalities per million inhabitants. However, it has to be mentioned that this is largely attributable to the 2004 disaster, in which, according to EM-DAT, 2,665 people died in Haiti and 688 in the Dominican Republic. This results in a total of 3,353 fatalities, which is a significant proportion of the total 3,931 fatalities from riverine floods in the Caribbean between 1950 and 2023.

4.1.2. Analysis of Project Funding Provided by the GCF and the AF

This subchapter provides the results of the analysis of the allocation of GCF and AF adaptation funding across climate-related hazards in non-Annex I countries. As mentioned in the Methodology, the total amount of funding was analysed since the opening of the two funds (i.e. 2010 to 2023 for the AF and 2015 to 2023 for the GCF).

General Analysis According to Hazard Types and Hazard Combinations

The following sections explain the results of the funding allocation analysis, which considered both projects that address only one type of hazard and projects that focus on several hazard types at once (i.e. hazard type combinations). The two tables below show how much funding was directed to each type of hazard and combination of hazards by the two funds individually (see Table 6) and when the amount of funding provided by both funds is combined (see Table 7).

Table 6: *Total amount of adaptation funding provided by the GCF and AF for projects addressing individual hazard types and hazard combinations in non-Annex I countries.*

		GCF		AF	
	Hazard Type / Combination	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**
Hazard Type	Riverine Floods	506.33	48.53%	65.39	39.69%
	Landslides	39.06	3.74%	7.43	4.51%
	GLOFs	36.96	3.54%	10.41	6.32%
	Snow Avalanches	0	0.00%	0	0.00%
Hazard Type Combination	Riverine Floods, Landslides	415.37	39.81%	81.53	49.49%
	Riverine Floods, Landslides, Snow Avalanches	45.63	4.37%	0	0.00%
		1,043.35	100.00%	**164.76**	100.00%

Table 7: *Total amount of adaptation funding provided by both the GCF and the AF for projects addressing individual hazard types and combinations in non-Annex I countries.*

		GCF and AF	
	Hazard Type / Combination	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**
Hazard Type	Riverine Floods	571.72	47.32%
	Landslides	46.49	3.85%
	GLOFs	47.37	3.92%
	Snow Avalanches	0	0.00%
Hazard Type Combination	Riverine Floods, Landslides	496.90	41.13%
	Riverine Floods, Landslides, Snow Avalanches	45.63	3.78%
		1,208.11	100.00%

Tables 6 and 7 show that the GCF has generally provided the most funding for riverine floods as a single hazard type, followed by the combination of riverine floods and landslides. The reverse is true for the AF (see Table 6). When the two funds are combined, the same pattern emerges in this respect as observed for the GCF alone (see Table 7). It is also noteworthy that neither the GCF nor the AF deal with snow avalanches as a separate hazard type. Snow avalanches are only addressed by the GCF through projects that also focus on riverine floods and landslides. GLOFs, on the other hand, are only targeted on their own, never in combination with other hazard types.

Table 8: *Total amount of GCF adaptation funding by hazard type and hazard combination in non-Annex I countries, depending on whether the project had a main or a minor focus on disaster risk reduction.*

	Hazard Type / Combination	**DRR - Main Focus**		**DRR - Minor Focus**	
		Funding [million USD]	**Percentage of the Total Amount of Funding [%]**	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**
Hazard Type	Riverine Floods	198.19	53.41%	308.14	45.83%
	Landslides	0	0.00%	39.06	5.81%
	GLOFs	36.96	9.96%	0	0.00%
	Snow Avalanches	0	0.00%	0	0.00%
Hazard Type Combination	Riverine Floods, Landslides	98.84	26.64%	316.53	47.08%
	Riverine Floods, Landslides, Snow Avalanches	37.05	9.99%	8.58	1.28%
		371.04	100.00%	**672.31**	100.00%

Table 8 again specifically shows the amount of adaptation funding provided by the GCF, but this time according to whether the funded project had a main or a minor focus on DRR. It can be seen that in general more money was spent on projects with a minor focus on DRR, almost twice as much as on projects with a main focus. It is also noteworthy that there are no projects addressing DRR as a main focus that tackle landslides or snow avalanches as individual hazard types. Furthermore, there is no minor focus project on DRR that only focuses on snow avalanches or GLOFs. Apart from GLOFs as a single hazard type, riverine floods, landslides and snow avalanches are the only hazard combination that received more funding through projects with a main focus on DRR than through those with a minor focus.

Analysis According to Individual Hazard Types

For the following figures, the funding amounts have been allocated to each hazard type, which means that hazard combinations are no longer taken into account. In this context, for example, the funding for a project dealing with both riverine floods and landslides will be doubled and allocated equally to both types of hazards. Figure 21 below displays the total funding amounts allocated to each climate-related hazard by fund, while Figure 22 shows the distribution of these amounts as percentages.

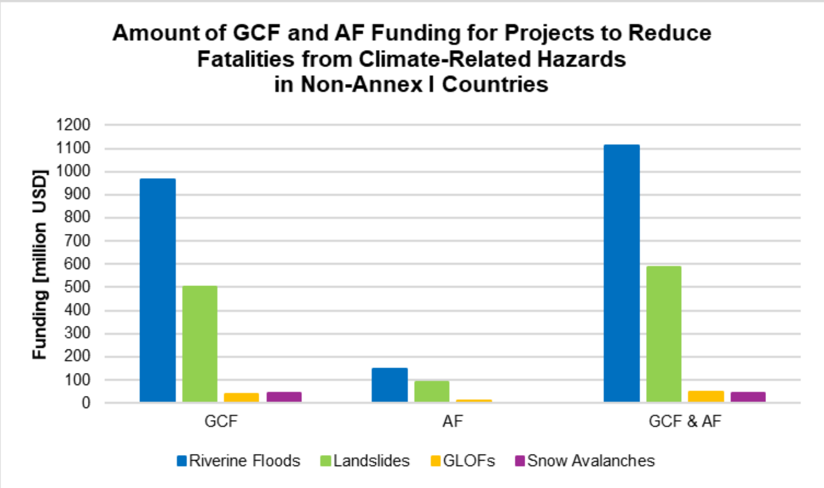

Figure 21: *Total amount of adaptation funding provided by the GCF and the AF for projects addressing individual hazard types in non-Annex I countries, by fund.*

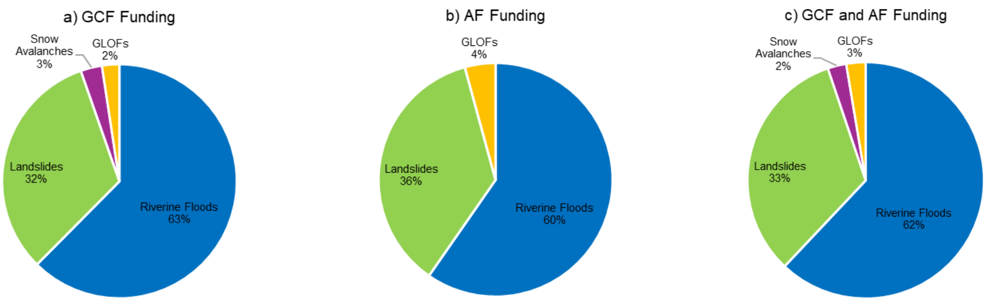

Figure 22: *Distribution of adaptation funding for projects addressing individual hazard types in non-Annex I countries provided by a) the GCF, b) the AF and c) both funds, expressed as a percentage.*

Both Figure 21 and Figure 22 show that riverine floods have received the most funding, followed by landslides, GLOFs and finally snow avalanches when the funding provided by the GCF and the AF is combined. However, looking at the two funds separately, the GCF has allocated slightly more funding to projects dealing with snow avalanches than GLOFs, while it is again noticeable that the AF has not funded any projects that address snow avalanches. Furthermore, in relative terms, it is visible that the

AF has invested slightly more of its funds in projects targeting landslides and GLOFs than the GCF (i.e. 36% instead of 32% and 4% instead of 2%).

Table 9: *Total amount of GCF adaptation funding by hazard type in non-Annex I countries, depending on whether the project had a main or a minor focus on disaster risk reduction.*

Hazard Type	**DRR - Main Focus**		**DRR - Minor Focus**	
	Funding [million USD]	**Percentage of the Total Amount of Funding [%]**	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**
Riverine Floods	334.09	61.41%	633.25	62.95%
Landslides	135.90	24.98%	364.16	36.20%
GLOFs	36.96	6.79%	0	0.00%
Snow Avalanches	37.05	6.81%	8.58	0.85%
	544.00	100.00%	**1,005.99**	100.00%

As in Table 8, Table 9 shows how much GCF funding has been invested in each hazard type, depending on whether the project had a main or a minor focus on DRR, but this time without taking into account the hazard combinations. It is clear that almost twice as much money was spent on projects with a minor focus on DRR than on projects with a main focus on DRR. Furthermore, in both focus categories, the largest amount of funding was provided for projects addressing riverine floods, followed by landslides, snow avalanches and then GLOFs. Again, it is striking that there is no project with a minor focus on DRR that addresses GLOFs.

Regional Analysis According to Individual Hazard Types

This section presents the results of the analysis focusing on regional differences in GCF and AF funding allocations, again considering Africa, Asia-Pacific, Latin America and the Caribbean, and Eastern Europe. The following two figures show the distribution of funding volumes by type of hazard in absolute amounts and as a percentage, similar to Figures 21 and 22. However, these figures only illustrate the combined amount of GCF and AF funding for the individual hazard types. The results of the analyses, which also include the hazard type combinations as well as tables and figures showing the differences between the two funds when only looking at individual hazard types, are given in Appendix B.

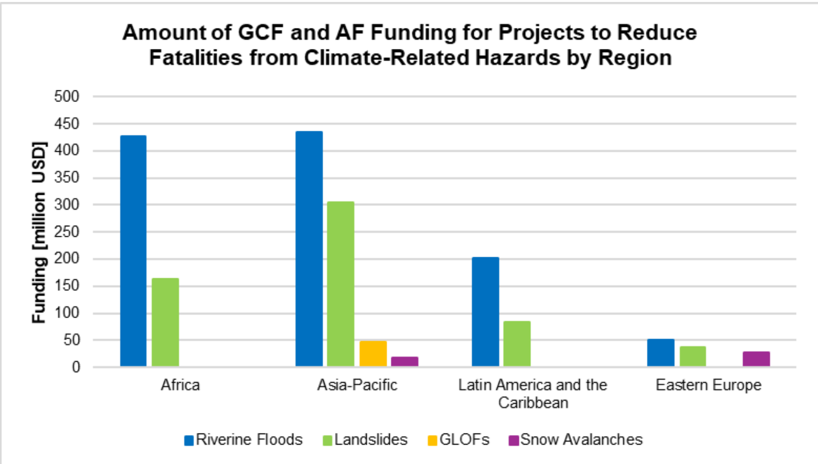

Figure 23: *Total amount of GCF and AF adaptation funding for projects addressing individual hazard types in non-Annex I countries, by region.*

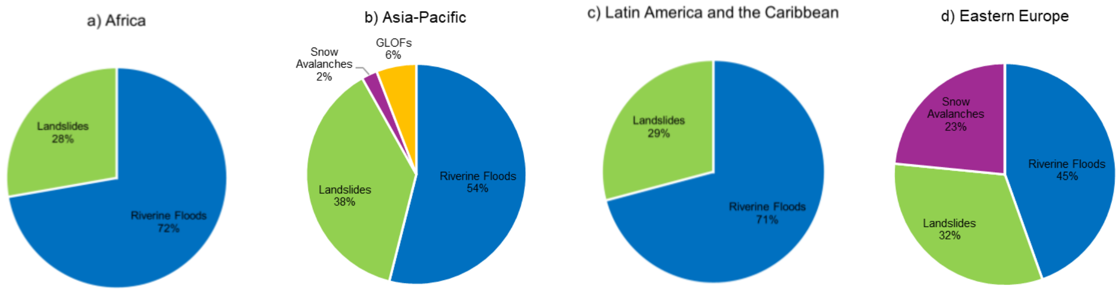

Figure 24: *Distribution of combined GCF and AF adaptation funding for non-Annex I countries, by hazard type and region, expressed as a percentage.*

Figure 23 and Figure 24 show that in all four regions, the largest GCF and AF investments were made in projects focusing on riverine floods, followed by landslides. In Africa and Latin America and the Caribbean, no money was spent on either snow avalanche or GLOF projects. This seems reasonable as snow avalanches and GLOFs do not occur in the Caribbean and very rarely in Africa. It is also noteworthy that in these two regions the proportion of funding for riverine floods and landslides was almost equal. Strikingly, Asia-Pacific is the only region where GLOFs were addressed through adaptation funding. When looking at the relationship between funding for GLOFs and funding for snow avalanches, it is clear that in the Asia-Pacific region, more funding was allocated to GLOFs than to snow avalanches. In Eastern Europe, it is noticeable that a significant amount of funding was invested in projects addressing snow avalanches.

4.1.3. Comparison of Fatalities and Funding Amounts

This subchapter presents the results of comparing the number of fatalities caused by climate-related hazards with the amount of adaptation funding allocated to these hazards. Table 10 provides the absolute funding amounts alongside the absolute number of fatalities. However, as it can be misleading to compare only absolute numbers of fatalities with absolute amounts of funding, an analysis of funding per fatality was also carried out, the results of which are presented in Figure 25 below.

Table 10: *Total number of fatalities in non-Annex I countries between 1950 and 2023 compared to the total amount of GCF and AF adaptation funding for the same countries, by climate-related hazard.*

	Total Number of Fatalities	**GCF Funding [million USD]**	**AF Funding [million USD]**	**GCF and AF Funding [million USD]**
Riverine Floods	124,422	967.33	146.92	1,114.25
Landslides	37,191	500.01	88.96	589.02
GLOFs	9,221	36.96	10.41	47.37

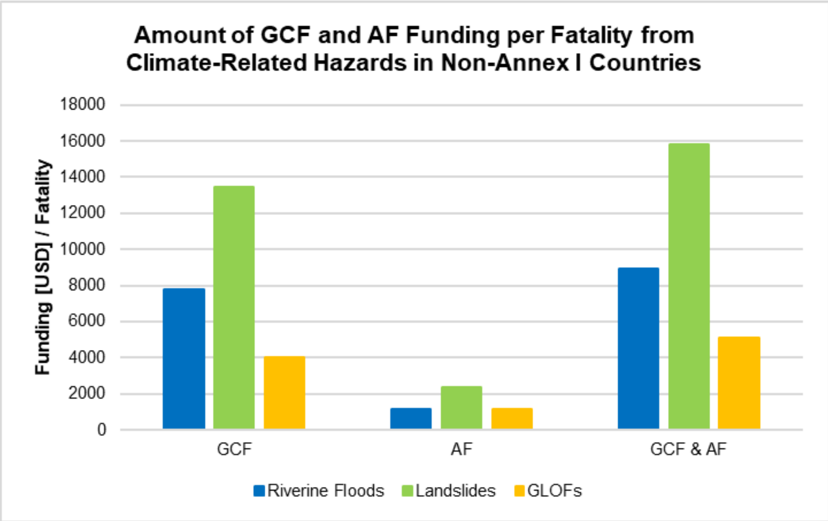

Figure 25: *Amount of adaptation funding per fatality provided by the GCF and the AF for projects addressing climate-related hazards in non-Annex I countries, by fund.*

Comparing the total number of fatalities directly with the total amount of funding, reveals a correlation (see Table 10). Thus, the climate-related hazards that caused the most fatalities between 1950 and 2023 were also those that were addressed most by project funding from the GCF and the AF. However, the results are different when looking at the amount of funding per fatality (see Figure 25). Irrespective of the fund, landslide projects received the most funding per fatality, followed by riverine floods and then GLOFs. A striking feature is that, for projects funded by the AF, the funding per fatality for riverine floods and GLOFs is very similar.

Regional Differences

The comparison of the number of fatalities caused by climate-related hazards and the allocation of adaptation funding volumes across these hazards was also carried out at the regional level, the results of which are shown in the following figures. While Figure 26 presents the financing amounts of each fund individually, Figure 27 displays the combined financing amounts of both funds.

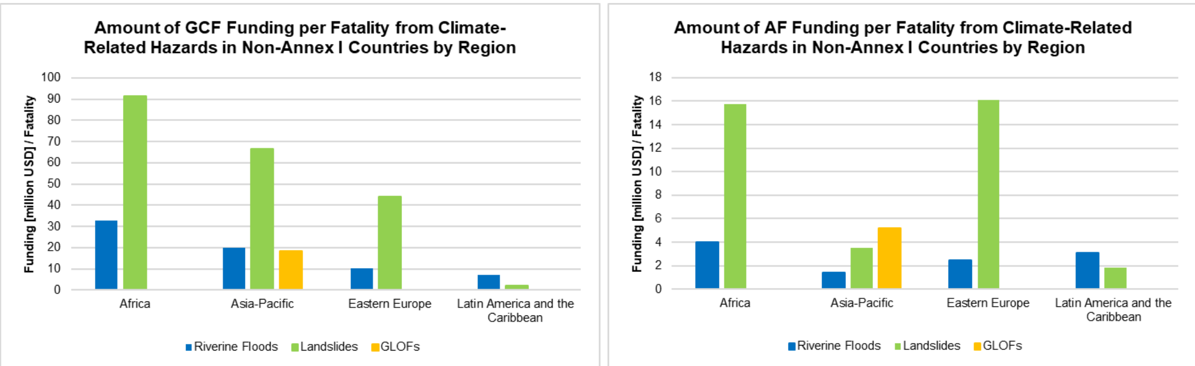

Figure 26: *Amount of adaptation funding per fatality provided by the GCF (left) and the AF (right) for projects addressing climate-related hazards in non-Annex I countries, by region.*

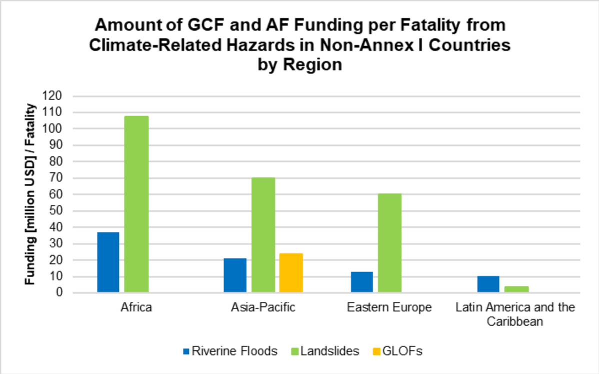

Figure 27: *Amount of adaptation funding per fatality provided by both the GCF and the AF for projects addressing climate-related hazards in non-Annex I countries, by region.*

As shown in Figures 26 and 27, the pattern of funding per fatality at the regional level is partly similar to that observed at the global level (see Figure 25). Irrespective of the fund, in Africa and Eastern Europe, funding per fatality was the highest for landslides, followed by riverine floods. For Latin America and the Caribbean, the opposite can be observed. In the Asia-Pacific region, there are different patterns depending on whether the GCF, the AF or both funds are considered together. When analysing GCF funding, the same pattern emerges as in the global analysis, i.e. the highest funding per fatality was provided for landslides, followed by riverine floods and finally GLOFs. However, if only AF funding is considered, the highest amount of funding per fatality was invested in GLOFs, the second highest in landslides and the lowest in riverine floods. When the funding of the two funds is combined, landslides rank first, GLOFs second and riverine floods third in terms of funding per fatality.

Temporal Trends

The graphs below in Figure 28 display the trend in fatalities and adaptation funding over time for each climate-related hazard. As mentioned in the Methodology, the analysis is mainly based on the date of submission of the concept note for GCF projects and on the time of project approval for AF projects. As a result, the graphs show a certain time lag for peaks in project funding, since the actual project cycle begins earlier. It should be noted that the curve for the volume of funding only shows peaks from 2010 onwards, because this is when the first projects were funded (see AF).

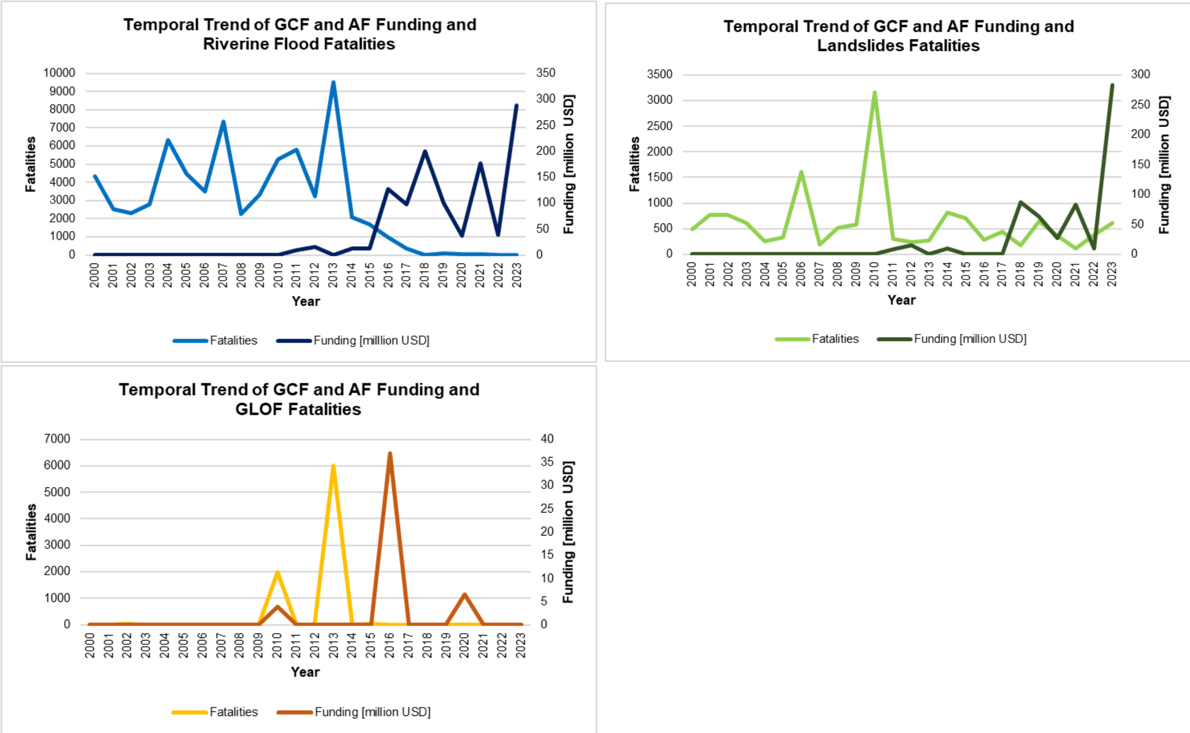

Figure 28: *Temporal trend of the number of fatalities and the amount of adaptation funding provided by the GCF and AF, by climate-related hazard.*

Figure 28 shows that in the case of riverine floods, there was a significant increase in funding shortly after the number of fatalities fell sharply. Since then, there has not been a single year in which no funding has been allocated to riverine flood projects, although some years have seen significantly more funding than others (i.e. 2016, 2018, 2021 and 2023). At the same time, however, the number of fatalities due to riverine floods was very low. Looking at the graph for landslides, there are peaks in both the number of fatalities and the amount of funding, but there is not a clear pattern as to whether a peak in the number of fatalities was directly followed by a peak in funding amounts. However, it can be seen that there was a relatively small peak in fatalities in 2019, while peaks in funding volumes are visible in 2021 and 2023. Another striking aspect is that, in general, the volume of funding for landslide projects has increased significantly since 2018. When analysing the graph for GLOFs, there are some significant peaks in both curves. It is striking that 2010 was a peak year for both the number of fatalities and the amount of funding. Furthermore, it is noticeable that after 2013, a year marked by many fatalities, funding increased significantly in 2016.

4.2. High Mountain Asia Analysis

4.2.1. Analysis of Fatalities Caused by Climate-Related Hazards

Analogous to the global analysis, this subchapter is devoted to the results of the fatality investigation in HMA, which was conducted using fatality data from riverine floods, landslides, GLOFs, and snow avalanches between 1972 and 2023. Table 11 again shows the calculated statistical measures of annual fatalities, some of which have been visualised in the boxplots shown in Figure 29.

__Table 11:__ Statistical measures calculated for the annual number of fatalities from riverine floods, landslides, GLOFs and snow avalanches in HMA for the period 1972-2023.

		Riverine Floods	Landslides	GLOFs	Snow Avalanches
Measures of Central Tendency	**Mean**	1,404.83	212.12	124.40	56.12
	Median	780	118	0	2
	Mode	0	0	0	0
Measures of Position	**1st Quartile**	0	67.75	0	0
	2nd Quartile (Mean)	780	118	0	2
	3rd Quartile	1,955	269	2.25	30.75
Measures of Dispersion	**IQR**	1,955	269	2.25	30.75
	Range	7,467	2,222	6,010	691
	Maximum	7,467	2,222	6,010	691
	Minimum	0	0	0	0
	Variance	2,877,839.87	108,613.16	693,507.70	19,022.26
	Standard Deviation	1,680.03	326.38	824.72	136.59

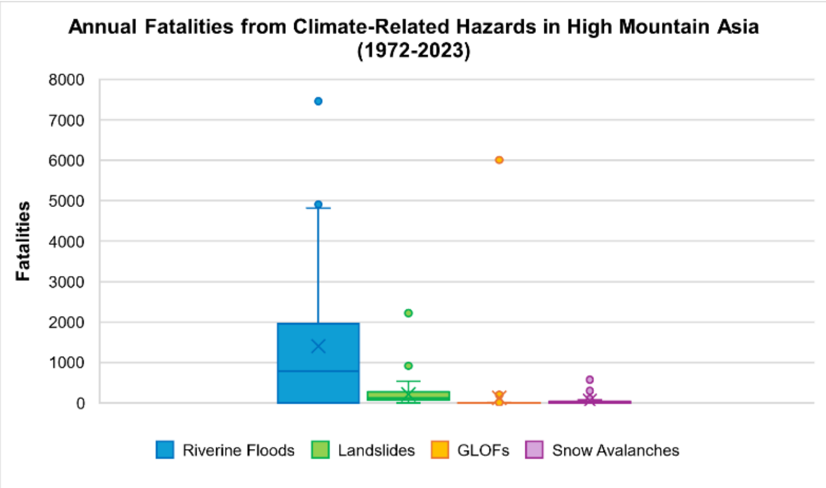

***Figure 29:** Boxplots for the annual number of fatalities from climate-related hazards in HMA between 1972 and 2023.*

Based on Table 11 with the calculated statistical measures and their visualisation as boxplots in Figure 29, it can be seen that in general there is a similar pattern in the annual number of fatalities from climate-related hazards as in the global analysis. Again, riverine floods have the highest median annual number of fatalities, but here it is not very close to the median annual number of fatalities from landslides, which is the second highest. It is also noteworthy that the median annual number of snow avalanche fatalities is slightly higher than that for GLOFs. However, the mean is lower, indicating that years with particularly high numbers of fatalities influence the data for GLOFs. It is also striking that for all four climate-related hazards, the mode is zero, which means that in most years between 1972 and 2023, none of the hazards resulted in fatalities.

Similar to the global analysis, the data for annual riverine flood fatalities show a greater dispersion compared to the other three climate-related hazards, as shown for example by the values for variance, standard deviation and IQR (see Table 11). This is further indicated by the particularly long upper whisker of the box plot, suggesting that there are a significant number of years with particularly high fatality rates. It is also striking that the IQR values of GLOFs and snow avalanches are extremely small, as visualized by the "compressed" boxes of the boxplots. Furthermore, for both hazard types (and also for riverine floods) the lower limit of the box is set at zero fatalities. This is in line with the fact that the mode is also zero for all three hazards (see above), as it further illustrates that a significant number of years were characterized by zero fatalities from riverine floods, snow avalanches and GLOFs. When looking at landslides, as in the global analysis, they are the only hazard type with a lower whisker and with a box whose lower limit is not set at zero fatalities. This again indicates that landslides were more likely to cause more than zero fatalities per year. However, these fatalities were generally lower than those for riverine floods, but higher than those for GLOFs and snow avalanches.

Another striking feature of the boxplots are the outliers. The boxplot for snow avalanches has the most outliers, seven in total, followed by GLOFs with six outliers, although for both hazards these are only visible when the y-axis is adjusted. This shows that for both hazards there were years where the number of fatalities was particularly high. When looking at riverine floods and landslides, there are only two outliers in each case. Generally, most noticeable are two outliers characterized by particularly high values, one of which is assigned to the boxplot for riverine floods and the other to the boxplot for GLOFs. As in the global analysis, these two outliers represent the year 2013, which was notably affected by the disaster in India (see chapter 4.1.1.). This event alone accounted for 6,054 of the 7,467 riverine flood fatalities that year. For GLOFs, 6,000 of the 6,010 fatalities in 2013 were associated with this event. As observed in the global analysis, these and other outliers have a significant impact on the statistical measures, especially in the case of GLOFs. For example, if the 2013 disaster in India is excluded from the GLOF database, the mean annual number of fatalities is reduced from 124.40 to 9.02, making it lower than the mean annual number of fatalities from snow avalanches. Additionally, disregarding this disaster also lowers the variance of annual GLOF fatalities from 693507.70 to 969.23 and the standard deviation from 136.59 to 30.83.

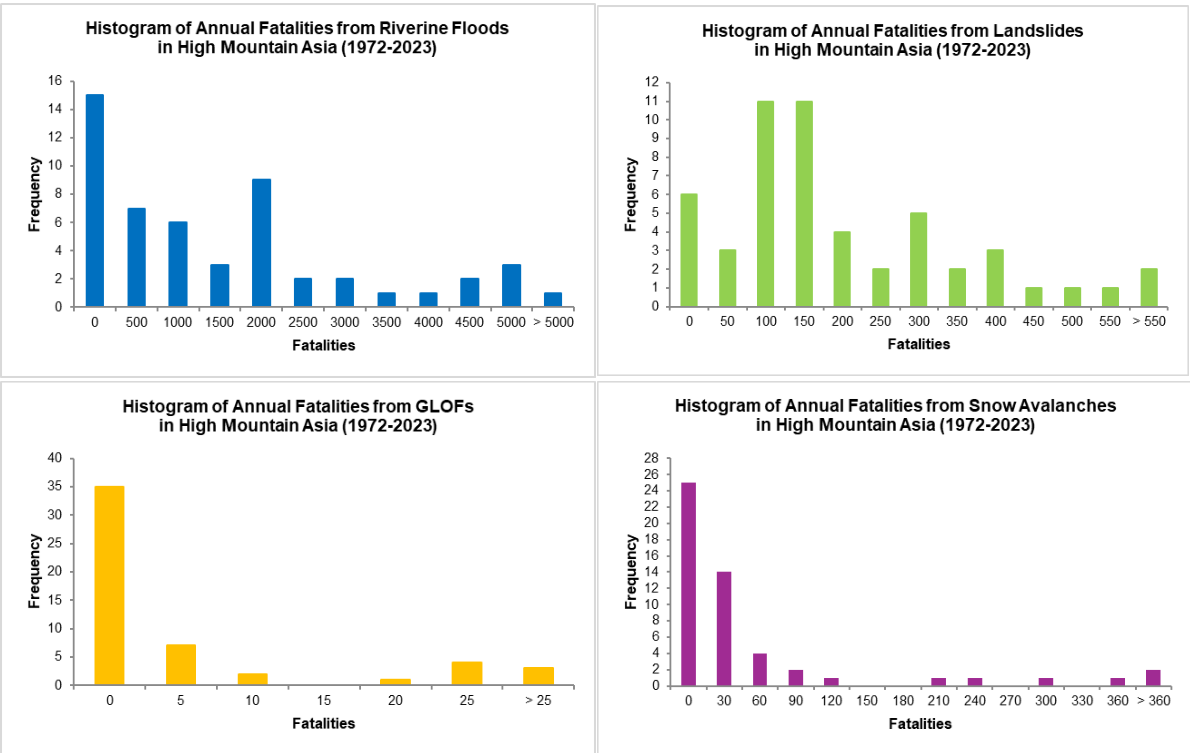

Figure 30: *Histograms for the annual number of fatalities from riverine floods (blue), landslides (green), GLOFs (yellow) and snow avalanches (purple) in HMA between 1972 and 2023.*

Analogous to the global analysis, Figure 30 shows histograms of the number of years between 1972 and 2023 characterized by a certain number of fatalities from a particular type of hazard. Looking at the results, it can be seen that in the case of riverine floods, there are many years with high numbers of fatalities, as indicated by the fatality categories on the x-axis. For landslides, the histogram again highlights that there were few years with no fatalities, in contrast to the other three hazard types. In addition, the number of years is relatively evenly distributed across the fatality categories. Another striking feature is that there were fewer years with zero fatalities from riverine floods and snow avalanches than years with zero fatalities from GLOFs.

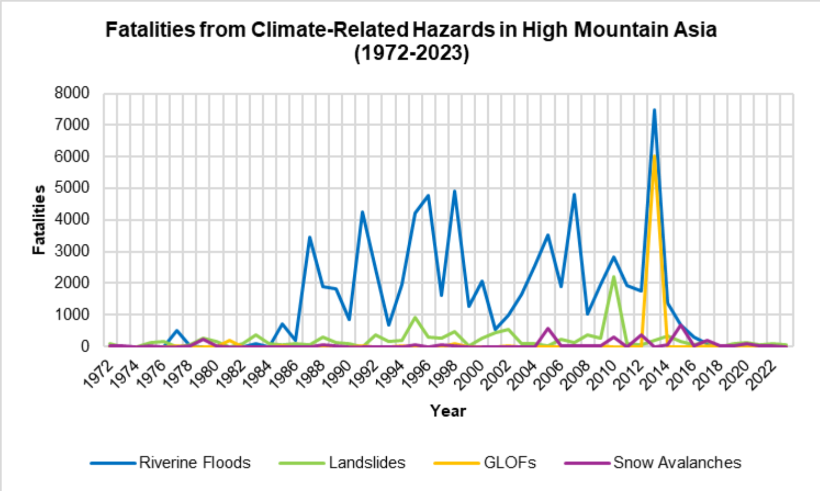

Figure 31: *Direct comparison of the annual number of fatalities from riverine floods (blue), landslides (green), GLOFs (yellow) and snow avalanches (purple) in HMA between 1972 and 2023.*

Figure 31 shows the direct comparison of annual fatalities from riverine floods, landslides, GLOFs, and snow avalanches. It can be seen that the trends in fatalities from all hazard types studied in HMA are relatively similar to those in non-Annex I countries at the global level. The figure illustrates once again that riverine floods caused the most fatalities, followed by landslides, snow avalanches and GLOFs. Here, too, the increase in riverine flood fatalities starting in the mid-1980s is evident, as is the subsequent rapid decline in the early 2010s. However, contrary to the global trend, there has also been a slight decrease in fatalities from landslides in recent years. While there is no trend for GLOFs, there appears to be a general increase in the number of snow avalanche fatalities compared to the pre-2005 period, or rather an increase in the number of years with particularly high numbers of fatalities.

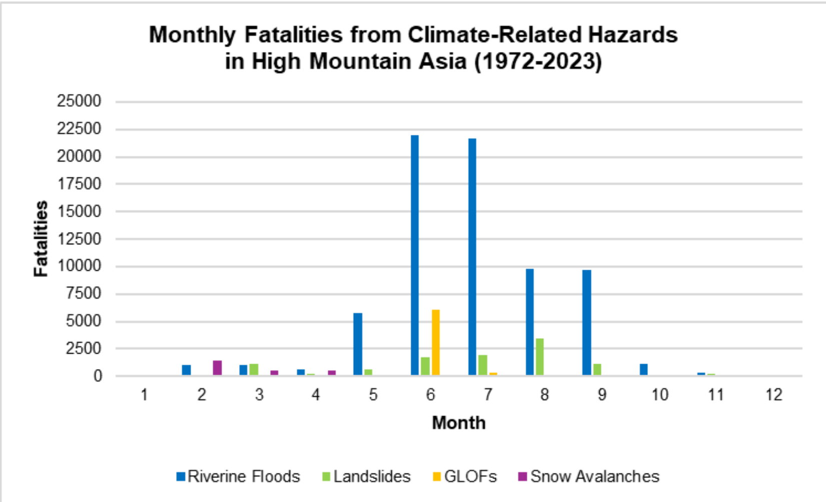

Figure 32: *Monthly fatalities from climate-related hazards in HMA.*

In Figure 32, it is illustrated how fatalities from climate-related hazards in HMA are spread across the months, again focusing on the period 1972-2023. In general, riverine flood fatalities are recorded every month, but in January, they are not visible on the graph as there are only 11 fatalities. The highest number of fatalities as a result of riverine floods is in the summer months, between May and September. This period coincides with increased snow and ice melt in HMA, which leads to higher river flows, as well as heavy monsoon rains, which can cause flooding. With regard to landslides, Figure 32 shows that the number of fatalities is much more constant over the months than the number of fatalities from riverine floods, as it is the case globally. Once again, there is no month without a landslide fatality. However, the majority of landslide fatalities occur in June, July, and August (see explanation above regarding increased snow and ice melt and monsoon rains). For GLOFs, fatalities also tend to occur in the summer months. As at the global level, the peak in fatalities occurs in June, with 6,000 of the total 6,040 fatalities attributed to the aforementioned 2013 disaster in India. July was also marked by a significant number of fatalities due to GLOFs (i.e. 325 fatalities). Other GLOF fatalities occur in April, August, September, and October, but the numbers are too small to be visible in the graph. Therefore, in summary it can be stated that no people died due to GLOFs in the winter months. As noted in the global analysis, the relatively high number of GLOF fatalities during the summer months may be partly attributed to rising temperatures, which increase the occurrence of ice avalanches that potentially hit glacial lakes. Additionally, melting ice and snow during this time of the year raises the levels of glacial lakes, further contributing to the risk. Heavy monsoon can also play a role by further increasing lake levels, adding pressure to the dam, and potentially triggering landslides that may impact the lake. When considering the monthly number of snow avalanche fatalities, the majority of people die in the late winter months (February) and spring months (March and April). At this time of the year, substantial amounts of snow have accumulated, and as winter ends, changing weather conditions, particularly rising temperatures, affect the stability of the snowpack, making it more susceptible to sliding. However, it is worth noting that snow avalanche fatalities also occurred between October and January, with numbers ranging from 16 in December to 132 in January. In addition, few fatalities were recorded in June (i.e. 12 fatalities) and July (i.e. 9 fatalities).

Local Analysis

Annual fatalities from riverine floods, landslides, GLOFs, and snow avalanches between 1972 and 2023 were also analysed at the local level for each country in HMA and for Bangladesh. The absolute numbers of fatalities are shown in Table 12, while the bar chart in Figure 33 represents the fatalities per million inhabitants for each country individually.

Table 12: *Total number of fatalities from riverine floods, landslides, GLOFs and snow avalanches in HMA between 1972 and 2023, by country.*

	Total Number of Fatalities			
Country	**Riverine Floods**	**Landslides**	**GLOFs**	**Snow Avalanches**
Afghanistan	2,572	483	15	884
Bangladesh	7,278	105	0	0
Bhutan	200	0	20	0
China	24,718	5,172	222	35
India	29,984	2,892	6,004	906
Kazakhstan	13	0	20	16
Kyrgyzstan	3	262	103	6
Nepal	1,784	1,649	52	597
Pakistan	6,329	222	8	357
Tajikistan	170	244	25	117
Uzbekistan	0	1	0	0

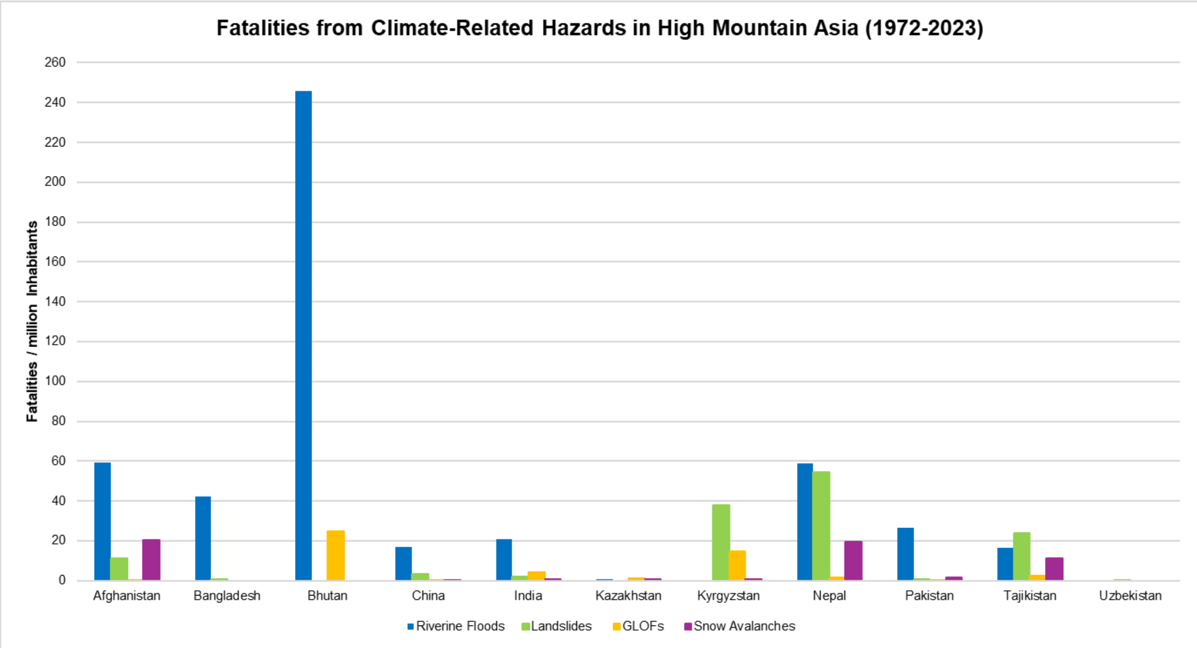

Figure 33: *Annual number of fatalities per million inhabitants from climate-related hazards in HMA between 1972 and 2023, by country.*

Based on the results displayed above, it can generally be stated that riverine floods caused the majority of fatalities in most countries. Exceptions are Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. As shown in Figure 33, in Bhutan in particular, riverine floods caused a significant number of fatalities per million inhabitants. This is due to a disaster in 2000 that killed 200 people, according to EM-DAT. As Bhutan has a small population compared to the other countries, this results in a large peak in fatalities. Another striking feature of Figure 33 is that the number of fatalities per million inhabitants was particularly low in Kazakhstan and Uzbekistan. In China and India, too, there are generally rather few fatalities per million inhabitants. It is important to note that these are relatively large countries with the majority of the population living outside mountainous areas, where hazards such as landslides, GLOFs, and snow avalanches are less relevant. This may contribute to the relatively low number of fatalities per million inhabitants. However, when analysing the absolute number of fatalities (see Table 12), India and China have the highest numbers, especially with respect to riverine floods, but also landslides and GLOFs. In addition, India is also marked by the highest absolute number of snow avalanche fatalities. With regard to Nepal, it is worth noting that it is the only country characterized by a relatively high number of fatalities per million inhabitants from all four climate-related hazards (except GLOFs). This reflects the fact that a particularly large proportion of Nepal's population lives in mountainous areas. In addition, Nepal is also the country that experiences the highest number of fatalities per million inhabitants from landslides, the second highest from snow avalanches and the third highest from riverine floods. It is also worth highlighting that no fatalities were recorded in Bangladesh due to GLOFs and snow avalanches, as these are not relevant hazards due to the country's low altitude and lack of mountainous terrain. With regard to Bhutan, it should also be noted that the avalanche fatality database did not contain any data for this country and therefore the number of avalanche fatalities is zero.

4.2.2. Analysis of Project Funding Provided by the GCF and the AF

In this subchapter, the results of the analysis of how the adaptation funding provided by the GCF and the AF is distributed across the climate-related hazards in HMA are presented. As in the global analysis, the focus was on the total amount of funding made available since the opening of the two funds.

General Analysis According to Hazard Types and Hazard Combinations

The following sections give details of the results of the GCF and AF funding allocation analysis, which looked at both projects addressing individual hazard types and those dealing with multiple hazard types simultaneously. The two tables below show the distribution of funds for each type of hazard and combination of hazard types when the two funds are considered separately (see Table 13) and when the funding amounts from both funds are combined (see Table 14).

Table 13: *Total amount of adaptation funding provided by the GCF and AF for projects addressing individual hazard types and hazard combinations in the countries of HMA.*

		GCF		AF	
	Hazard Type / Combination	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**
Hazard Type	Riverine Floods	9.68	13.03%	10.00	48.99%
	Landslides	0	0.00%	0	0.00%
	Snow Avalanches	0	0.00%	0	0.00%
	GLOFs	36.96	3.41%	10.41	51.01%
Hazard Type Combination	Riverine Floods, Landslides	218.40	77.01%	0	0.00%
	Riverine Floods, Landslides, Snow Avalanches	18.58	6.55%	0	0.00%
		283.62	100.00%	**20.41**	100.00%

Table 14: *Total amount of adaptation funding provided by both the GCF and the AF for projects addressing individual hazard types and combinations in the countries of HMA.*

		GCF and AF	
	Hazard Type / Combination	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**
Hazard Type	Riverine Floods	19.68	6.47%
	Landslides	0	0.00%
	Snow Avalanches	0	0.00%
	GLOFs	47.37	15.58%
Hazard Type Combination	Riverine Floods, Landslides	218.40	71.84%
	Riverine Floods, Landslides, Snow Avalanches	18.58	6.11%
		304.03	100.00%

The results shown in Table 13 indicate that the GCF has invested three-quarters of its financial resources in projects addressing the combination of riverine floods and landslides. In this respect, GLOF projects come in second place, followed by projects that focus simultaneously on riverine floods, landslides and snow avalanches and then projects that address only riverine floods. Neither landslides nor snow avalanches have been addressed as individual hazard types by GCF funding. In the case of the AF, almost 50% of its funding went to projects dealing exclusively with riverine floods, while the remaining 50% was invested in GLOF projects. Combining the funding volumes of the two funds follows almost the same pattern as for the GCF, except that more funding was invested in projects addressing riverine floods as a single hazard type than in projects focusing on the hazard combination of riverine floods, landslides and snow avalanches (see Table 14).

__Table 15:__ Total amount of GCF adaptation funding by hazard type and hazard combination in the countries of HMA, depending on whether the project had a main or a minor focus on disaster risk reduction.

	Hazard Type / Combination	DRR - Main Focus		DRR - Minor Focus	
		Funding [million USD]	Percentage of the Total Amount of Funding [%]	Funding [million USD]	Percentage of the Total Amount of Funding [%]
Hazard Type	Riverine Floods	0	0.00%	9.68	4.09%
	Landslides	0	0.00%	0	0.00%
	Snow Avalanches	0	0.00%	0	0.00%
	GLOFs	36.96	78.71%	0	0.00%
Hazard Type Combination	Riverine Floods, Landslides	0	0.00%	218.40	92.29%
	Riverine Floods, Landslides, Snow Avalanches	10.00	21.29%	8.58	3.62%
		46.96	100.00%	**236.66**	100.00%

Table 15 shows the GCF funding amounts according to whether the projects had a main or a minor focus on disaster risk reduction. In general, it can be seen that most of the funding went to projects with a minor focus on disaster risk reduction. Furthermore, the funding amounts for projects with a main focus on disaster risk reduction were only allocated to GLOFs as a single hazard type or to riverine floods, landslides and snow avalanches in combination. In terms of projects with a minor focus on disaster risk reduction, almost all of the funding was directed at the combination of riverine floods and landslides. The remainder was almost equally divided between projects focusing on riverine floods, landslides and snow avalanches simultaneously and projects addressing riverine floods only.

Analysis According to Individual Hazard Types

As with the global analysis, the tables and figures below show the results of the analysis, where the amount of funding was allocated to each climate-related hazard in the case of projects that target several hazards at once (i.e. hazard combinations).

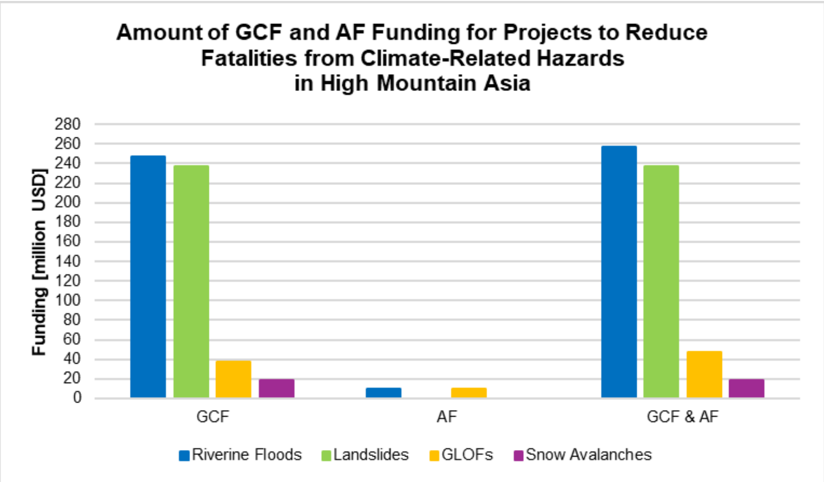

***Figure 34:** Total amount of adaptation funding provided by the GCF and the AF for projects addressing individual hazard types in the countries of HMA, by fund.*

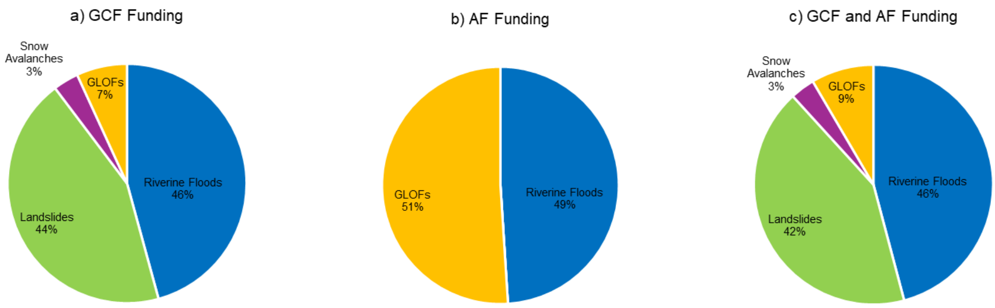

Figure 35: *Distribution of adaptation funding for projects addressing individual hazard types in the countries of HMA provided by a) the GCF, b) the AF and c) both funds, expressed as a percentage.*

Figures 34 and 35 illustrate how much GCF and AF funding has been allocated to projects addressing specific climate-related hazards. It is visualised n that GCF funding has been directed mainly towards riverine floods, closely followed by landslides, GLOFs and then snow avalanches. Looking at the AF, which generally addressed only riverine floods and GLOFs, funding was almost equally divided between the two hazards, with GLOFs receiving slightly more funding. If the funding amounts of both funds are combined, the pattern is almost identical to the one when only GCF funding is taken into account.

Table 16: *Total amount of GCF adaptation funding by hazard type in the countries of HMA, depending on whether the project had a main or a minor focus on disaster risk reduction.*

Hazard Type	**DRR - Main Focus**		**DRR - Minor Focus**	
	Funding [million USD]	**Percentage of the Total Amount of Funding [%]**	**Funding [million USD]**	**Percentage of the Total Amount of Funding [%]**
Riverine Floods	10.00	14.93%	236.66	50.12%
Landslides	10.00	14.93%	226.98	48.07%
Snow Avalanches	10.00	14.93%	8.58	1.82%
GLOFs	36.96	55.20%	0	0.00%
	66.96	100.00%	**472.22**	100.00%

When distinguishing between GCF projects with a main focus on disaster risk reduction and those with a minor focus, Table 16 shows that in general most of the funding went to projects with a minor focus on disaster risk reduction. While about half of the funding for projects with a main focus on disaster risk reduction was allocated to GLOFs, with the remainder being equally divided between projects focusing on riverine floods, landslides and snow avalanches, projects with a minor focus on disaster risk reduction generally did not address GLOFs at all. Hence, funding for projects with a minor focus on disaster risk reduction was mainly targeted at riverine floods and landslides, while a small amount of funding was directed at snow avalanches.

Local Analysis According to Individual Hazard Types

Figure 36 shows the allocation of combined GCF and AF funding by country in HMA, with the full amount of funding attributed to each country in the case of projects covering more than one country. It should be noted that, as with the global analysis, pie charts have been produced to show the percentage of funding per hazard and per country, which can be found in Appendix C. Furthermore, figures showing the results when the two funds are considered separately can also be found in Appendix C.

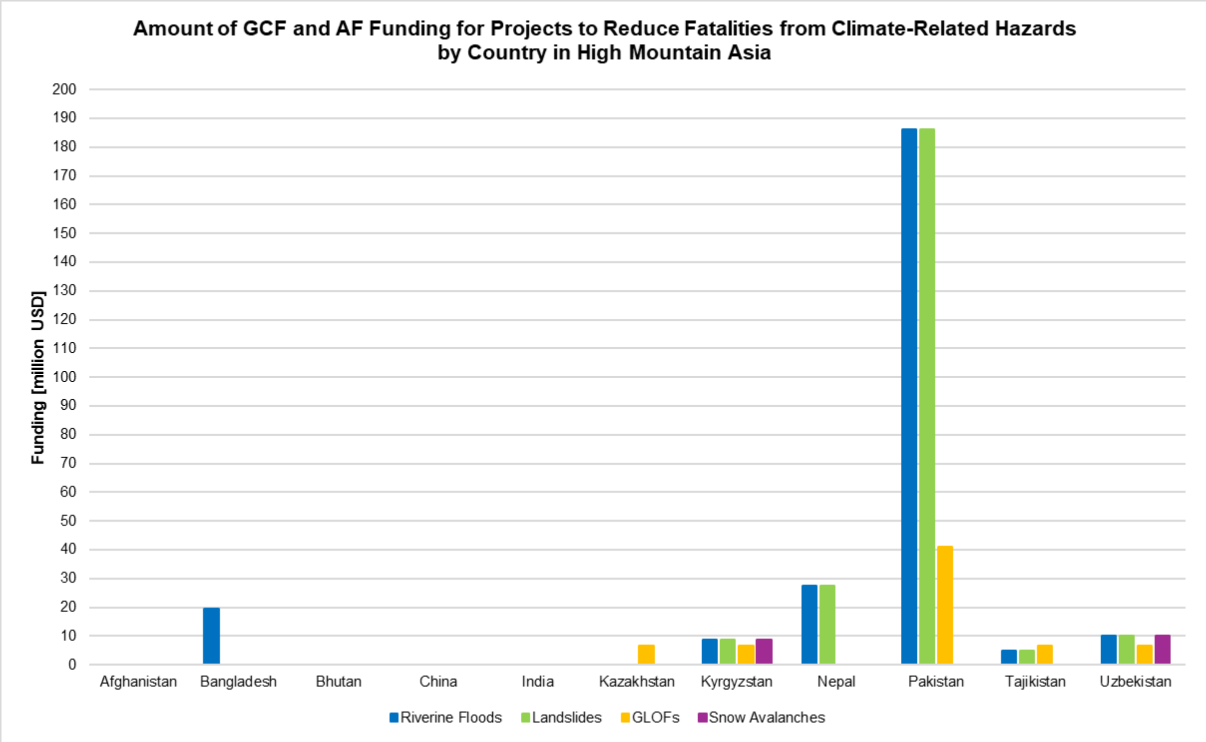

Figure 36: *Total amount of GCF and AF adaptation funding for projects addressing individual hazard types in HMA, by country.*

In Figure 36, it is noticeable that there are a number of countries in which no projects have been funded, namely Afghanistan, Bhutan, China and India. Relatively high levels of funding were concentrated on projects in Pakistan, with particularly large amounts of funding allocated to projects dealing with riverine floods and landslides, but also GLOFs. The funding amounts for riverine floods and landslides are from a single project and are therefore equal. It is also striking that only in Kyrgyzstan and Uzbekistan have snow avalanches been the tackled with GCF and AF funding. GLOFs, on the other hand, were addressed in five countries, four of which (Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan) were the target of a single AF project, which is why the funding allocations are the same.

4.2.3. Comparison of Fatalities and Funding Amounts

This subchapter is devoted to the results of the comparison of the number of fatalities from climate-related hazards with the amount of funding allocated to these hazards. As at the global level, Table 17 shows the total number of fatalities and the total amount of funding from each fund and the two funds combined, while Figure 37 displays the amount of funding provided per fatality by fund in a bar chart.

Table 17: *Total number of fatalities in the countries of HMA between 1972 and 2023 compared to the total amount of GCF and AF adaptation funding for the same countries, by climate-related hazard.*

	Total Number of Fatalities	GCF Funding [million USD]	AF Funding [million USD]	GCF and AF Funding [million USD]
Riverine Floods	73,051	246.66	10.00	256.66
Landslides	11,030	236.98	0	236.98
GLOFs	6,469	36.96	10.41	47.37
Snow Avalanches	2,981	18.58	0	18.58

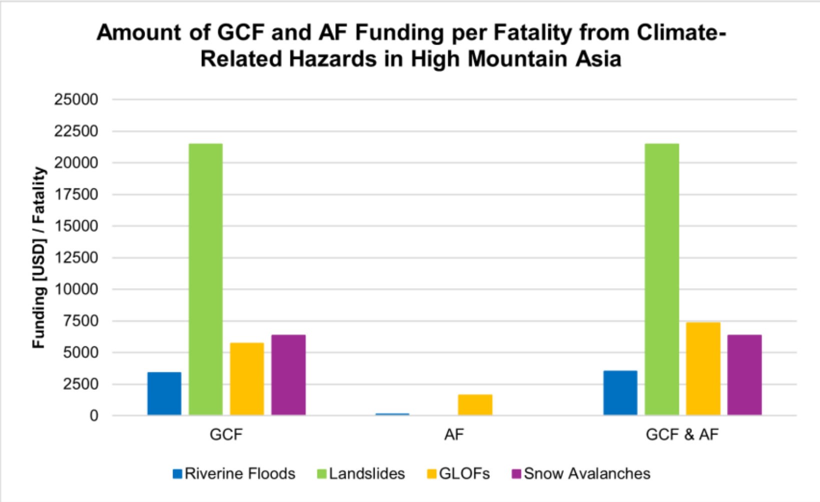

Figure 37: *Amount of adaptation funding per fatality provided by the GCF and the AF for projects addressing climate-related hazards in HMA, by fund.*

Comparing the absolute number of fatalities with the absolute amount of funding provided for each type of hazard, Table 17 shows for the GCF that the climate-related hazards with the highest fatality rates were also the ones that received the most funding. However, this is not the case when looking only at the AF, which, as noted above, has focused exclusively on GLOF or riverine flood projects. Nevertheless, combining the funding amounts of the two funds, the pattern is again similar to that observed when only the GCF funding is considered. When looking at the results of the analysis focusing on the amount of funding per fatality, as shown in Figure 37, it is clear that the GCF has invested most in projects dealing with landslides, followed by snow avalanches, GLOFs and finally riverine floods. However, the AF has invested most of its funding in GLOFs and a relatively small proportion in riverine floods. Combining GCF and AF funding, the picture is again similar to that when looking at GCF alone, except that more funding has been invested in GLOFs than in snow avalanches due to the substantial amounts of AF funding for GLOFs.

Regional Differences

Figure 38 below shows the correlation between the amount of combined GCF and AF funding and the number of fatalities per million inhabitants with each dot representing a country and a climate-related hazard (see colouring). Additional tables are included in Appendix C, which provide more detailed information on the exact numbers regarding the fatalities and the amounts of funding. In addition, as with the regional analysis conducted at the global level, the amount of funding per fatality was analysed for each country and each fund. These results can also be found in the Appendix C.

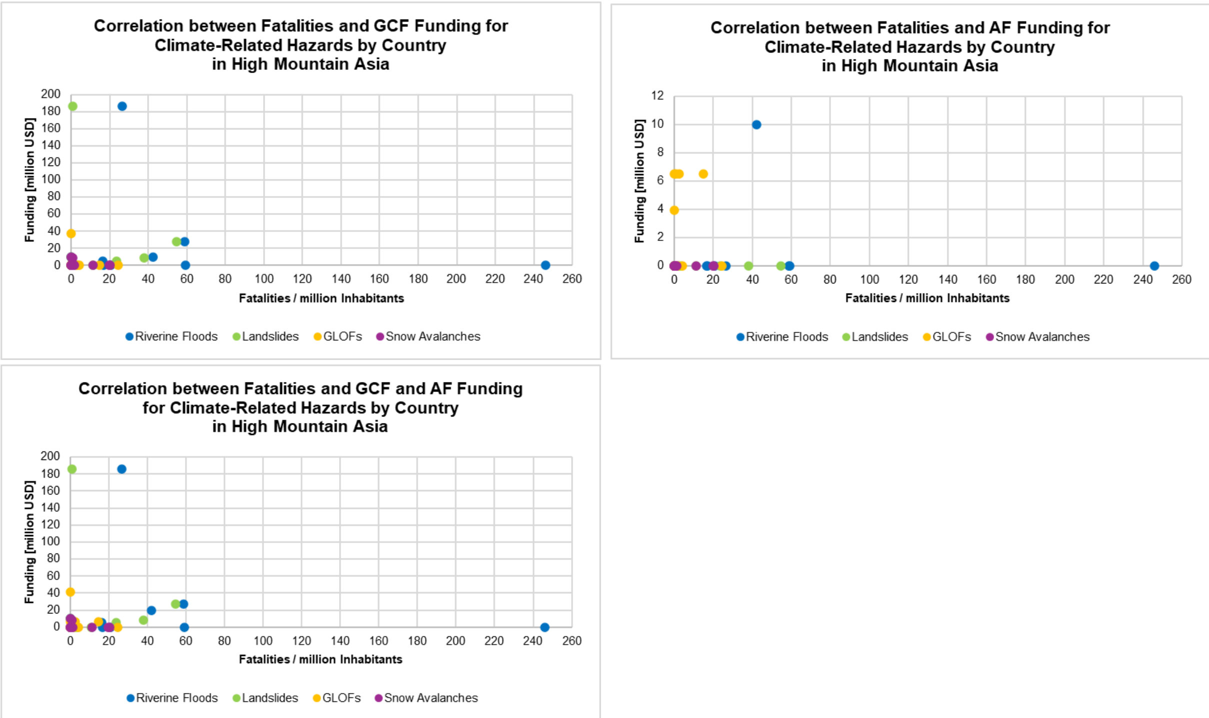

Figure 38: *Correlation between the number of fatalities and the amount of adaptation funding provided by the GCF (upper left), the AF (upper right) and both funds (lower left) for projects addressing climate-related hazards in HMA.*

It is immediately apparent from Figure 38 that there is no clear positive correlation between the number of fatalities per million inhabitants and the amount of funding. Thus, if a hazard type causes a significant number of fatalities per million inhabitants, this is not necessarily accompanied by a high level of funding. At best, a minimal correlation can be assumed when looking at the funding provided by the GCF and the combined amounts of GCF and AF funding. However, there are some dots in the scatter plot that are clearly out of line, which is particularly evident in the graph showing AF funding amounts. Thus, there are four countries (Uzbekistan, Tajikistan, Kyrgyzstan and Pakistan) where GLOFs have not caused many fatalities per million inhabitants, but have still been addressed with relatively high levels of funding (see yellow dots). Another example in the graphs showing GCF funding and combined GCF and AF funding are the green and blue dots, marked by particularly high amounts of funding, which represent landslides in Pakistan and riverine floods in Pakistan, respectively. In the same two scatter plots, there is also a blue dot showing an extremely high number of fatalities per million inhabitants, but no funding (i.e. riverine floods in Bhutan).

Temporal Trends

Figure 39 below shows, as in the global analysis, whether peaks in fatalities associated with a particular climate-related hazard were followed by peaks in combined GCF and AF funding for projects addressing the same hazard. Again, the time lag mentioned in the previous chapter must be considered.

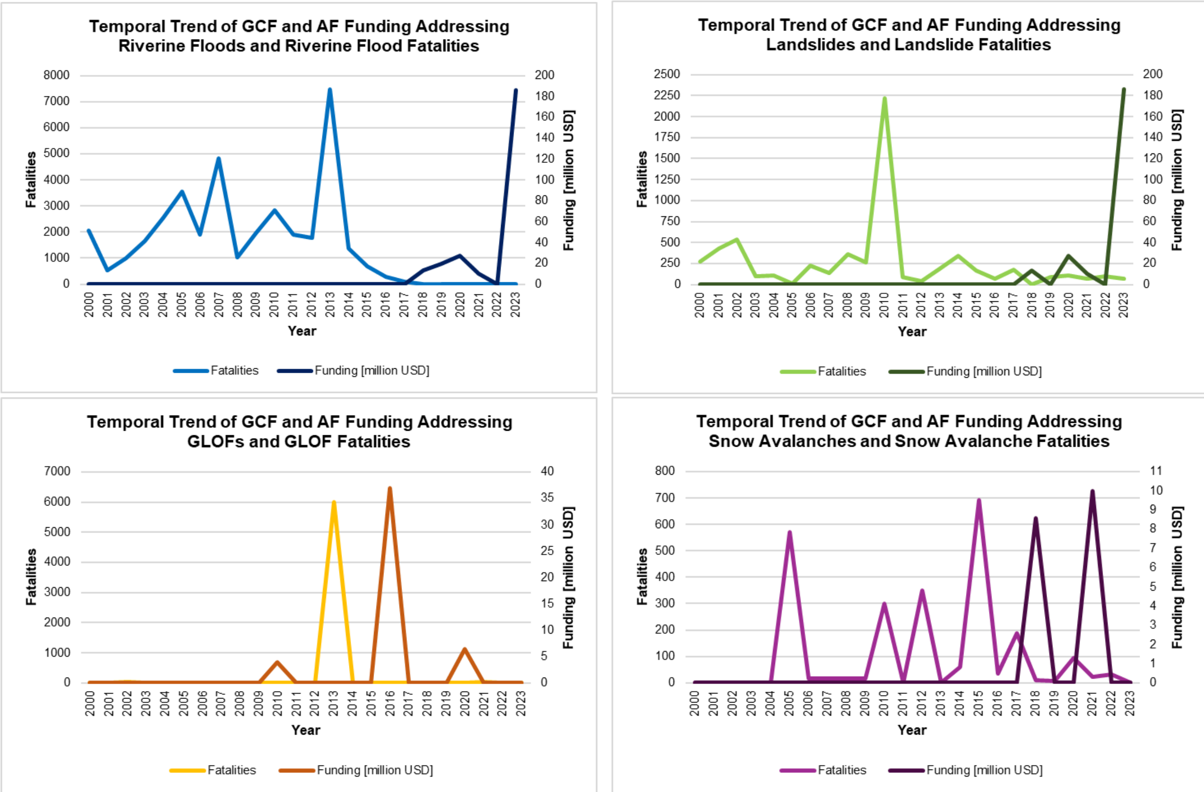

Figure 39: *Temporal trend of the number of fatalities and the amount of adaptation funding provided by the GCF and AF, by climate-related hazard.*

Looking at the graph for riverine floods in Figure 39, there is no clear identified pattern. After the rapid decline in fatalities from 2013 onwards, the funding amounts increased, but not significantly. However, there is a substantial peak in funding in 2023. Strikingly, there is no clear pattern in the landslide graph either. The amount of funding increased after 2017, but as with riverine floods, there is no strong trend. The landslide graph also shows a significant peak in funding in 2023. Regarding GLOFs, as in the global analysis, a high number of fatalities in 2013 was accompanied by high amounts of funding invested in GLOF projects in 2016. Looking at the graph for snow avalanches, the funding amounts for snow avalanche projects exhibit two peaks, one in 2018 and one in 2021, while there was a significant peak in fatalities a few years earlier, in 2015, and a smaller peak in 2017.

5. Discussion

The following sections critically assess and interpret the results presented in chapter 4 in order to answer the four research questions posed in the context of this Master's thesis:

1. What climate-related hazards represent the greatest risk, defined by the highest number of fatalities, to developing countries and specifically High Mountain Asia countries?
2. How is adaptation funding, provided by the GCF and the AF allocated among adaptation projects targeting specific climate-related hazards?
3. How do the societal impacts (fatalities) from climate-related hazards assessed in the course of this Master's thesis align to the distribution of adaptation funding?
4. What other factors influence the allocation of adaptation funding?

Each research question is addressed in a subchapter, while at the end there is a section describing the uncertainties and limitations of this Master's thesis, which must be taken into account when interpreting the results.

5.1. Fatality Analysis

Global (Non-Annex I Countries)

The results of the fatality analysis reveal that, in terms of absolute fatalities, riverine floods are the deadliest hazard (124,422 fatalities) at the global level in non-Annex I countries between 1950 and 2023, followed by landslides (37,191 fatalities) and then GLOFs (9,221 fatalities) (see Results). This pattern is consistent with the results derived from other statistical measures, for example the median annual number of fatalities, which also shows the highest value for riverine floods, then landslides, and finally GLOFs. Based on these findings, it can be deduced that projects aimed at reducing the number of fatalities caused by riverine floods should receive the largest share of funding, following projects on landslides and projects on GLOFs.

On the global scale, as indicated in the Methodology, no analysis of snow avalanche fatalities has been carried out due to the limited data available on global fatalities. However, a single statement was found in a publication by Schweizer et al. (2021), where it is mentioned that "the number of avalanche fatalities per year due to snow avalanches is estimated to be about 250 worldwide" (Schweizer et al., 2021, p. 395). Based on this figure, the number of snow avalanche fatalities globally between 1950 and 2023 would be around 18,500. This is lower than the absolute fatalities due to riverine floods and landslides, but significantly higher than the absolute fatalities caused by GLOFs. Bearing in mind that this is an oversimplification and that this figure of 250 fatalities per year probably includes deaths of mountain recreationists (i.e. people who actively expose themselves to the risk), it still leaves room to assume that, on a global scale, snow avalanches are responsible for a significant number of fatalities, probably more than GLOFs. However, this would need to be investigated further with more precise data.

High Mountain Asia

The analysis of fatalities carried out for HMA, which also includes snow avalanches as a climate-related hazard, reveals a more complex picture. When analysing the absolute number of fatalities between 1972 and 2023, the result is similar to that at the global level. Riverine floods caused the most fatalities (73,051), followed by landslides (11,030), GLOFs (6,469) and finally snow avalanches (2,981). If only absolute numbers were taken into account, the climate-related hazards would have to be addressed in the same order as at the global level in terms of funding volumes, with snow avalanches receiving the least. However, it should be noted that of the total 6,469 fatalities from GLOFs, 6,000 were associated with a single disaster in India (Uttarakhand) in 2013, which is also the reason why 2013 stands out as the top outlier in the GLOF boxplot (see Results). This disaster is exceptional for its particularly severe societal impact, not only within the GLOF dataset, but also when compared to the data for riverine flood, landslide and snow avalanche disasters. If this disaster is excluded from the analysis, the absolute number of GLOF fatalities is reduced to 469 fatalities between 1972 and 2023, which is significantly less than the absolute number of fatalities due to snow avalanches. It should also be noted that if one considers the annual number of fatalities rather than the absolute number of fatalities between 1972 and 2023, snow avalanches appear to be more deadly than GLOFs. The median of annual fatalities from snow avalanches, which is not influenced by outliers (i.e. years with particularly high numbers of fatalities), is slightly higher than for GLOFs. As shown in the histograms, annual snow avalanche fatalities are more constant and generally at a higher level than GLOF fatalities. For this reason, it could be argued that snow avalanches should receive more adaptation funding than GLOFs. This illustrates that the decision as to which climate-related hazard should be funded to the greatest extent depends on which perspective is assumed regarding the lethality of a hazard.

5.2. Project Funding Analysis

As already explained, the results of the project funding analysis, which does not take into account combinations of hazard types, show that, on the global scale, the highest amount of funding, regardless of the fund, was allocated to projects dealing with riverine floods, followed by landslides. In terms of funding for reducing GLOF and snow avalanche fatalities, the GCF invested more in snow avalanches than in GLOFs, while the AF did not invest in snow avalanches at all, only in GLOFs. When the funding amounts of the two funds are combined, GLOFs received slightly more funding than snow avalanches. Looking at HMA, the results of the project funding analysis show that most funding has been allocated to riverine floods, closely followed by landslides, then GLOFs and finally snow avalanches, when considering combined GCF and AF funding as well as GCF funding alone. If only AF funding is taken into account, GLOF projects received the most funding, closely followed by riverine floods, while projects on landslides and snow avalanches were not financially supported.

However, as already indicated in the Methodology, funding levels are generally overestimated in the context of this thesis. On the one hand, this is due to the fact that for projects addressing several types of hazards at once (i.e. hazard combinations), the full amount of project funding has been allocated to each hazard. On the other hand, some GCF projects do not exclusively address disaster risk reduction but are also focusing on other sectors (e.g. water management or agriculture). Nevertheless, the full amount of project funding was always used for further analysis. Therefore, the results above need to be critically assessed by placing them in the context of the project funding allocation analysis by hazard type and combination and the analysis distinguishing between GCF projects with a main focus on DRR and those with a minor focus.

Global (Non-Annex I Countries)

With regard to the analysis of funding amounts for hazard types and combinations, at the global level, it was found that projects focusing exclusively on riverine floods received a high amount of funding (e.g. USD 571.71 million of GCF and AF funding), while projects addressing only landslides as a single hazard type were significantly less funded (e.g. USD 46.49 million of GCF and AF funding). Thus, most of the funding for landslides came from projects that addressed landslides together with either riverine floods (e.g. USD 496.90 million of GCF and AF funding) or with riverine floods and snow avalanches (e.g. USD 45.63 million of GCF and AF funding). This suggests that the funding amounts for riverine floods are significantly less overestimated than for landslides, supporting the finding that riverine floods received more funding than landslides. This applies not only to the combined GCF and AF funding, but also when looking at the funds individually. Regarding GLOF projects, it is clear that GLOFs were never addressed by either the GCF or the AF in combination with other hazard types, but only as a single hazard type, which leads to the conclusion that the GLOF funding amounts are relatively accurate. The opposite is true for snow avalanches, which are only dealt with in combination with riverine floods and landslides, resulting in a significant overestimation of funding.

Assessing GCF funding amounts in the context of whether projects had a main or a minor focus on DRR reveals that only DRR minor focus projects addressed landslides as an individual hazard type. Furthermore, for projects addressing landslides in combination with riverine foods, which account for the largest share of funding for landslides, funding was also rather invested in minor focus projects (USD 316.53 million) than in main focus projects (USD 98.84 million). This leads to a further overestimation of funding for landslides. Regarding riverine floods, a significant amount of funding addressing riverine floods alone came from projects with a minor focus on DRR (i.e. USD 308.14 million compared to USD 198.19 million for projects with a main focus on DRR). However, it can be seen that the volume of funding for projects solely on riverine floods with a main focus on DRR are still higher than for DRR main focus projects that only concentrate on landslides. When looking at GLOFs, the results of the analysis show that they have only been addressed through projects with a main focus on DRR, further highlighting the relative accuracy of the funding amounts identified in the context of this Master's thesis. Snow avalanches, which, as noted above, were only addressed in combination with riverine floods and snow avalanches, received more funding through main focus projects (USD 37.05 million) than minor focus projects (USD 8.58 million), resulting in a comparatively lower overestimation.

Taking into account that the overestimation related to the DRR project focus is less decisive for the general results than the overestimation related to the multiplication of funding for projects dealing with combinations of hazards, the overall conclusion is that the funding amounts for projects dealing with GLOFs are the most accurate, while the funding amounts for the other three hazard types tend to be overestimated, especially for landslides and snow avalanches. With this in mind, looking only at GCF funding amounts, it can be stated that the order in which the hazards were categorized may be slightly different in reality. Thus, contrary to what the analysis suggested, snow avalanches may actually be addressed by less funding than GLOFs. However, with regard to the funding provided by the AF and the combined GCF and AF funding volumes, it can be stated that the order determined in this context is appropriate.

High Mountain Asia

In HMA, a closer look at hazard types and combinations reveals a similar picture to that observed at the global level. Projects on riverine floods as a single hazard type received more funding (e.g. USD 19.68 million of GCF and AF funding) than projects on landslides as a single hazard type, but this time, landslides were not addressed individually at all, either through GCF or AF funding (note that generally only the GCF dealt with landslides in HMA). All of the funding for landslides came from GCF projects that also addressed riverine floods (USD 218.49 million) or riverine floods and snow avalanches (USD 18.58 million). In this context, it has to be mentioned that there are several reasons why riverine floods and landslides are addressed together in a single project. In general, they are often related hazard types because, as suggested in the Theoretical Background, they can be triggered by the same processes (e.g. heavy rainfall) and can initiate or reinforce each other. Furthermore, they often occur in similar geographical areas, such as river valleys in mountainous regions, which is why communities are often vulnerable and exposed to both hazard types at the same time. Because of this connection, there are adaptation measures and strategies that can be taken to reduce the number of fatalities from both hazards at the same time. Examples include early warning systems for heavy rainfall or flooding, or Ecosystem-based Adaptation (e.g. restoration of vegetation and forests) (Adler et al., 2022). Nevertheless, as a result, the funding amounts for landslides used in this analysis are greatly overestimated, more so than they are overestimated for riverine floods, but the difference is not as pronounced as at the global level. Looking at the other two hazard types, GLOFs and snow avalanches, it should be noted that, as at the global level, snow avalanches are never addressed as a single hazard type in a project, but always in combination with riverine floods and landslides. GLOFs, on the other hand, are always targeted separately. Against this background, the funding amounts for snow avalanches tend to be overestimated, while they are relatively accurate for GLOFs.

When analysing the distribution of GCF project funding by DRR focus, riverine floods were only addressed by projects with a minor DRR focus, except when they were tackled together with landslides and snow avalanches. Thus, a total of USD 236.66 million was spent on riverine floods through minor focus projects, while USD 10 million were spent through major focus projects on DRR. A similar pattern was observed for landslides. Therefore, the funding amounts for riverine floods and landslides are greatly overestimated in this respect. For snow avalanches, slightly more funding was spent on projects with a main focus on DRR (USD 10 million) than on projects with a minor focus on DRR (USD 8.58 million). With regard to GLOFs, this is the only hazard type where funding was only invested in main focus projects. As a result, while funding for snow avalanche projects is partially overestimated, GLOF funding is again the most accurate when compared to all climate-related hazards.

As on the global level, based on these two analyses, it can be concluded that the funding amounts determined in the context of this thesis are most accurate for GLOFs. An overestimation of funding can be deduced especially for landslides and snow avalanches, but also for riverine floods. However, it can be assumed that this only affects the ratio between the funding amounts for the individual hazard types, but does not change the order in which the four climate-related hazards are ranked in terms of funding amounts.

5.3. Comparison of Fatalities and Project Funding

Global (Non-Annex I Countries)

As described in the results, at the global level, regardless of which fund is analysed, the most funding per fatality was invested in projects dealing with landslides, followed by riverine floods and GLOFs. Given that riverine floods cause more fatalities than landslides, the conclusion to be drawn from these results is that GCF and AF funding is not addressing the deadliest climate-related hazards to the greatest extend. However, it has to be considered that, as mentioned above, the funding amounts for landslides are estimated too high in this analysis, significantly more so than for riverine floods. This also exaggerates the amount of funding per fatality. It is therefore likely that riverine floods actually receive more funding per fatality than landslides, although this analysis suggests otherwise. It is also interesting to note that when only looking at AF funding, the amount of funding per fatality for riverine flood projects is only slightly higher than for GLOFs. Since funding for riverine floods is also overestimated compared to funding for GLOFs, it is possible that GLOFs are actually receiving more funding per fatality than riverine floods, even though riverine floods cause significantly more fatalities.

As mentioned above, snow avalanches have not been analysed in this context due to the limited data on fatalities at the global level. However, if snow avalanches are included in this analysis by considering the 18,500 fatalities described above, the funding per fatality would be approximately 2,466.49 USD (45,630,000 USD / 18,500 fatalities) if only GCF and combined GCF and AF funding are looked at. If only AF funding is considered, there would be no funding per fatality as the AF did not fund snow avalanche projects. Nevertheless, the 2,466.49 USD per fatality for snow avalanches is significantly lower than the funding per fatality for riverine floods, landslides and GLOFs. However, as mentioned above, the number of fatalities used for this analysis is probably not appropriate for this analysis, so this will not be discussed further.

High Mountain Asia

When looking at HMA, the results regarding the amount of funding per fatality depend on which fund is examined. Considering the GCF, most funding per fatality was spend on projects focusing on landslides, snow avalanches, GLOFs and finally riverine floods. For the AF, most funding per fatality was directed towards measures addressing GLOFs, with riverine floods coming in second. Combining the two funds, the results of this analysis show that the highest amount of funding per fatality went to projects dealing with landslides, followed by GLOFs, snow avalanches and riverine floods. However, as at the global level, these rankings do not reflect the fatality rate of each hazard. If one considers that the hazard with the highest absolute number of fatalities should receive the most funding per fatality, then riverine floods should be ranked first, landslides second, GLOFs third and snow avalanches last. However, if, based on the explanations above, snow avalanches are considered to be more deadly overall than GLOFs, then snow avalanches should be funded more than GLOFs. Therefore, as it is the case at the global level, none of the funds is targeting the hazards that cause the greatest number of fatalities with the largest amount of adaptation funding.

Looking more closely at the results of the analysis regarding funding per fatality in HMA, it is striking that the difference between the funding per fatality for riverine floods and for landslides is very large when looking at GCF funding and combined GCF and AF funding. This is because the number of fatalities from landslides is much lower (11,030) than for riverine floods (73,051), while the amount of funding is relatively similar for both hazard types. Again, it should be noted that the amount of funding allocated to projects dealing with landslides is more overestimated than that allocated to projects addressing riverine floods. However, it can be assumed that this cannot make up for the huge difference in funding per fatality between riverine floods and landslides, as the overestimation of funding for riverine floods is not significantly less than for landslides. Another striking feature of the results of the HMA analysis is that GLOFs tend to receive more funding per fatality than snow avalanches (unless only GCF funding amounts are considered). But since snow avalanches are never addressed on their own, the funding amounts per fatality tend to be overestimated for snow avalanches, while they are relatively accurate for GLOFs, since they are never addressed with other types of hazards. Taking this into account, it can be presumed that in reality snow avalanches have received less funding per fatality than GLOFs. As already mentioned, this result was also obtained when considering AF and combined GCF and AF funding, but not when considering GCF funding alone.

5.4. Other Factors Influencing Funding Allocation

It is important to note that the reason why adaptation funding is not necessarily allocated according to the number of fatalities from climate-related hazards is not only due to the approach chosen for the analysis as elaborated above, but also because there are many other factors that influence where the funding is channelled. Several of these factors are discussed in the following sections, some of which are general drivers of funding allocation, while others may specifically influence which climate-related hazards are funded and to what extent.

GCF and AF Funding Allocation Criteria

Probably the most important factor to mention is the criteria set by the GCF and the AF to guide the allocation of funds, reflecting their priorities and strategies. Since both funds are part of the UNFCCC's climate finance mechanism (see Theoretical Background), the criteria are placed in the broader context of the global climate change goals defined by the UNFCCC. Investing in climate change adaptation is therefore not only about addressing the most urgent risks, respectively those hazards that cause the highest number of fatalities, but also about ensuring that projects are generally consistent with the global climate change framework, which overall seeks to achieve long-term resilience and sustainability in the face of a changing climate.

With regard to the GCF, there are a total of six criteria that are considered in the GCF's investment decisions and in the review of funding proposals for adaptation, mitigation and cross-cutting projects. They are defined in the GCF Investment Framework (see GCF, 2023b, p. 3). Similar to the GCF, the AF has also established a set of "criteria", although not referred to as such, which are based on the framework outlined in the "Strategic Priorities, Policies, and Guidelines of the Adaptation Fund (SPPG)" document (see AF, 2022b, pp. 3–4). It has to be noted that the criteria of the two funds are to a large extent overlapping. Examples are the level of vulnerability of the recipient country, the social, economic and environmental benefits of the project or the overall project cost-effectiveness. The full list of criteria for both funds can be found in Appendix D.

How these criteria might be applied can be illustrated by the example of China. This country is eligible for GCF and AF funding, but has not received any adaptation funding for projects to reduce the number of fatalities from climate-related hazards, despite being frequently affected by severe flooding events, as evidenced by the high total number of fatalities. Furthermore, when looking at all GCF and AF projects, including those not included in this analysis, there is only one cross-cutting project funded by the GCF that targets China. As can be seen in Appendix D, one of the GCF criteria is "needs of the recipient", which includes "economic and social development level of the country and the affected population" (GCF, 2023b, p. 3). China is a relatively rich country compared to other non-Annex I countries and has a large economy, as evidenced by its high GDP per capita (World Bank, 2024). This particular aspect may contribute to the GCF tending to channel financial resources to other countries. As a side note, another possible reason for the specific lack of adaptation projects in China may be that this country is one of the world's largest GHG emitters, as illustrated, for example, by the Emissions Database for Global Atmospheric Research (Crippa et al., 2023). This could lead to less emphasis being placed on adaptation projects in China, as mitigation is seen as a greater need.

Political Factors

Apart from the official GCF and AF criteria mentioned above, it is likely that other factors also influence the funds' decisions on where the funding should be allocated. In this context, it is worth adding that a country's political stability can also play a role. International climate funds may be reluctant to provide financial resources for projects in countries characterized by political tensions and conflict, as their capacity and readiness to implement adaptation projects could be limited. This assumption is supported by Rivera Macedo (2021), who investigated in the context of her Master's thesis whether the most vulnerable countries receive the most adaptation funding. The main finding was that not only a country's vulnerability plays a role in the decision-making process on where to channel funds, but also its readiness to implement adaptation projects, which depends not only on political factors, but also on other aspects, such as social and economic stability (Rivera Macedo, 2021). An example of a country where this may apply is Afghanistan. Thus, according to The Fund for Peace's "Fragile States Index", based on 12 conflict risk indicators (cohesion, social, political and economic indicators), Afghanistan is one of the most fragile countries in the world (FFP, 2024). Despite the fact that Afghanistan suffers from a significant number of fatalities due to climate related disasters, particularly as a consequence of riverine floods, the results of this analysis show that no adaptation funds have been allocated to this country.

Another factor to be mentioned in this context is that in the case of projects involving several countries, which are particularly needed for addressing hazards that affect large areas (e.g. riverine floods), political tensions between affected countries can lead to lack of interest in funding adaptation projects there.

Potential examples include China and India, which have a long history of geopolitical conflict and, as reflected in the results of the country level analysis for HMA, have not been addressed by adaptation funding.

Economic Impacts of Climate-Related Disasters

As a third factor, it can be noted that stakeholders who implement adaptation projects do not necessarily aim to reduce the societal impacts of climate-related hazards, but in some cases are more concerned with their economic impacts. In fact, there are Accredited Entities (see AF) and Implementing Entities (see GCF) that in general prefer to initiate projects focusing on the economic impacts of climate-related hazards. One example is the World Bank, an international financial organization with the overall aim of achieving economic development and poverty reduction (see official Webpage).

Against this background, funding decisions may be more driven by those hazards that cause large economic losses than those that kill the most people. For example, climate-related hazards such as floods or droughts can lead to agricultural losses, which can disrupt livelihoods and ultimately increase the vulnerability of communities (Ahmad et al., 2022; Parvin et al., 2016). In addition, climate-related hazards can damage essential facilities, such as transport or utility infrastructure (Verschuur et al., 2024). This can have a negative impact on economic activity and productivity by restricting the flow of goods and the movement of people, and by disrupting critical services (e.g. electricity or water) (Çevik, 2024). The project analysis conducted for this Master's thesis identified many adaptation projects, particularly those funded by the GCF, that focus on the economic impacts of climate-related hazards such as those mentioned above. For example, some GCF projects seek to increase agricultural productivity (e.g. GCF, 2018a) or improve food security through improved soil and water management (e.g. GCF, 2016a), while other projects aim to improve marked access for smallholder farmers by rehabilitating critical infrastructure (e.g. GCF, 2019).

Perception of Climate Change and Hazard Connections

Since both the GCF and the AF are dedicated to addressing the impacts of climate change, it is reasonable to expect that hazards that are more closely linked to climate change will receive more funding, as this maximizes the positive impact of adaptation projects in the context of climate change. This focus may partly explain why projects dealing with certain hazards, such as snow avalanches, have received less funding than projects addressing other hazards, for example GLOFs, even though snow avalanches also pose a significant risk. As can be read in the Theoretical Background, the relationship between climate change and altering GLOF hazard is more direct and widely acknowledged. GLOFs are often seen as a symbol of climate change because of their association with melting glaciers, which form lakes whose waters can be released catastrophically (see Chapter 2.2.4.). However, the link between climate change and altering snow avalanche hazard is less straightforward. While it was emphasized in Chapter 2.2.3. that changes in snow avalanche hazard are complex and multi-faceted, the perception is often that climate change is leading to a decline in snow cover, from which it is concluded that snow avalanche hazard is decreasing. These aspects could lead to GLOFs being given a higher priority in decision-making on the allocation of adaptation funding.

On the other hand, it should be noted that local communities often perceive GLOFs as "acts of God" that are difficult to predict and avoid (Huggel et al., 2020), which may affect the allocation of adaptation funding. As Huggel et al. (2020) point out, "when a resident believes sinning causes floods or coca leaf offerings presented to mountain deities stabilize glacier lakes - as opposed to the scientific conclusions attributing these processes to climate change, glacier shrinkage, and bedrock geometry - then development and implementation of risk reduction plans become more difficult, because not everyone agrees about the source of the hazard" (Huggel et al., 2020, p. 2186). As a result, adaptation funding may be directed towards other hazards, such as snow avalanches, which are recurring events each winter and therefore appear more preventable.

Perception of Spatial and Temporal Hazard Characteristics

In addition to the perception of the relationship between climate change and hazards, the spatial and temporal characteristics of hazards can also influence decisions on where to allocate adaptation funding, which can again be illustrated by the examples of snow avalanches and GLOFs. Snow avalanches are typically considered to be a seasonal phenomenon that is spatially more limited, as they are usually observed in high altitudes where population density is relatively low. GLOFs, on the other hand, also occur in mountainous regions, but are less seasonal and their impacts are much more extensive, affecting downstream communities over a much wider area. This perception of GLOFs as a more threatening hazard due to their characteristics may lead to a higher interest in dealing with GLOFs than with snow avalanches. Furthermore, the fact that GLOFs are characterised by far-reaching impacts may further result in the perception that these events affect innocent downstream communities, whereas snow avalanches are viewed as affecting those people and buildings that are in the "wrong" (i.e. exposed) places.

Disaster-Driven Funding Allocation

Another factor influencing the allocation of adaptation funding concerns major disasters, which attract a high degree of attention and create a sense of urgency and interest in addressing the hazards involved in these events. A concrete example that can be cited in this context is an adaptation project funded by the GCF, with the title "Recharge Pakistan: Building Pakistan's resilience to climate change through Ecosystem-based Adaptation (EbA) and Green Infrastructure for integrated flood risk management". This project was added to the project pipeline on the 19th August 2019 and, as the title suggests, addresses flood risk in Pakistan by focusing on ecosystem-based adaptation and green infrastructure. It can be deduced from the funding proposal that this project has been driven to a significant extent by the severe flooding in Pakistan in Summer 2022 (see GCF, 2023a), which, according to EM-DAT, was primarily caused by exceptionally heavy monsoon rains. The disaster affected 33 million people and resulted in 1,739 deaths (see CRED, 2023b). However, the significant number of fatalities due to this disaster were not considered in the fatality analysis because this event was categorized under "Flood (General)" rather than "Riverine Floods" (see Uncertainties and Limitations). Another, though less straightforward, example is a GCF-funded adaptation project called "Scaling-up of Glacial Lake Outburst Flood (GLOF) risk reduction in Northern Pakistan", the concept note for which was received on the 30th of May 2015. The project aims to reduce the risk of GLOFs in Pakistan through various measures, including engineering works (e.g. drainage), early warning systems and weather monitoring stations. Based on the Approved Funding Proposal, it appears that this project was also motivated by past GLOF events in Pakistan, including the 2010 disaster involving the Booni Gole Glacier, but also the major flood disaster in Pakistan that occurred in the same year (see Uncertainties and Limitations below for more information on these two events) (see GCF, 2016b).

It is worth noting that this disaster-driven allocation of adaptation funding is closely related to the broader issue of proactive and reactive adaptation. Anticipatory (proactive) adaptation is defined as "adaptation that takes place before impacts of climate change are observed" (IPCC, n.d.), while reactive adaptation refers to "adaptation that takes place after impacts of climate change have been observed" (IPCC, n.d.). The IPCC notes that adaptation, and therefore adaptation funding, is predominantly reactive (Mimura et al., 2014). However, "prospective (proactive) disaster risk management and adaptation can contribute in important ways to avoiding future, and not just reducing existing, risk and disaster once they have become manifest, as is the case with corrective or reactive management" (IPCC, 2012a, p. 36). This underlines that proactive adaptation (e.g. through DRR measures and strategies) offers a more sustainable approach (IPCC, 2012a). Furthermore, it is worth noting that proactive adaptation is more cost-effective, as highlighted for example by Neumann et al. (2021) in the context of climate change impacts on infrastructure. On this basis, it can be argued that the disaster-driven funding allocation described above (i.e. reactive adaptation) may be less effective in the long-term.

5.5. Uncertainties and Limitations

EM-DAT

The analysis of fatalities associated with climate-related hazards is subject to a number of uncertainties and limitations that need to be taken into account when interpreting the results of the study. Some of these relate to the international disaster database EM-DAT, which has been used to analyse fatalities due to riverine floods and landslides both globally and for HMA countries. One aspect is the fact that EM-DAT does not record all disaster events, but only those that meet at least one of the following criteria (CRED, 2024):

1) "At least ten deaths (including dead and missing)"
2) "At least 100 affected (people affected, injured, or homeless)"
3) "A call for international assistance or an emergency declaration"

For this reason, it is likely that some events with few deaths were not entered into the database and where therefore not included in the analysis for this thesis, resulting in an underestimation of fatalities.

Another limitation of the fatality analysis, which is also related to the EM-DAT database, specifically concerns riverine floods. In this study, only disaster events recorded under the category "Riverine Floods" have been analysed. However, there is also a category in the database called "Floods (General)", which includes riverine flood events, some of which resulted in particularly high numbers of fatalities (sometimes more than 10,000). Examples are disasters in Bangladesh in 1960 and 1974 or in China in 1954. It should be noted, however, that fatalities in these events were often not only due to riverine floods, but also to cascading and compounding events (Hamidifar & Nones, 2023). Nevertheless, this leads to a further underestimation of riverine flood fatalities in this analysis.

A further limitation associated with the EM-DAT disaster database relates specifically to landslides. Fatality from landslides is significantly underestimated in EM-DAT, as shown, for example, by Kirschbaum et al. (2015) and Petley (2012). This is largely due to the fact that landslides are considered as a secondary hazard, resulting in fatalities being attributed to the primary hazard (Froude & Petley, 2018).

GLOF Databases

In general, it is important to bear in mind that databases on disasters and their fatalities can be marked by inaccuracies. In the context of this Master's thesis, this was particularly evident in the GLOF databases, as illustrated by the following two examples.

1) A significant GLOF event that occurred in Peru in December 1941 (Lake Palcacocha) was entered into the global database, but no fatalities were recorded. However, there are several scientific studies indicating that at least 1,800 people lost their lives as a result of this disaster (e.g. Somos-Valenzuela et al., 2016). It has to be noted that this event does not affect the results of the fatality analysis as it occurred before 1950, but is nevertheless an illustrative example.

2) The global database contains a GLOF disaster related to the Booni Gol Glacier in Pakistan that occurred in July 2010 and resulted in 1,980 fatalities. This event was also included in the HMA database, but there is no entry for fatalities. The global database took the information on the death toll from a Twitter post made by the UNDP Pakistan on the 7th of July 2018 (UNDP, 2018b). The Tweet

contains a link to an article on the official UNDP Pakistan website, entitled "Government of Pakistan launches US$37 million UNDP-supported project to protect some 30 million people from dangerous glacial lake outburst floods and other climate change impacts" (UNDP, 2018a). This article elaborates on the impact of this GLOF event by stating that "in 2010 the Booni Gol Glacier, located near Chitral, generated an outburst flood that killed 1,980 people, injured an additional 2,946 more, and destroyed some 1.6 million homes" (UNDP, 2018a). Further research on this event has revealed that although there are sources that discuss this event, there are no other (scientific) sources that confirm that the number of fatalities is correct. At most, there are sources (online news articles) that refer to the UNDP article. However, there was another major disaster in Pakistan in the same month of the same year. The regions of Balochistan, lower Punjab, Sindh and Khyber Pakhtunkhwa in Pakistan experienced severe flooding due to heavy monsoon rainfall impacting the Indus River and its tributaries (Hashmi, 2012). According to a publication by the Centre for Research on the Epidemiology of Disasters (CRED) and the United Nations Office for Disaster Risk Reduction (UNDRR), these floods caused 1,985 fatalities (CRED & UNDRR, 2020). As this death toll is very similar to that recorded in the global database for the GLOF disaster, there is reason to believe that the fatalities from these floods were falsely attributed to the GLOF event.

Against this background, these examples demonstrate that there is always a need to be aware of errors and to be critical in the use of these databases.

In addition to general database inaccuracies, it should be noted again that there are also GLOF disasters recorded in the global and HMA databases that resulted in fatalities, but for which no precise figures were provided. As explained in the methodology, assumptions have been made about the number of fatalities for these events, which adds some uncertainty to the analysis. However, it can be assumed that these are generally rather small events, so this does not have a significant impact on the results of the analysis, but should still be pointed out.

General Uncertainties and Limitations in Connection with Disaster Databases

Apart from these specific aspects, there are also general uncertainties and limitations associated with disaster databases containing information on fatalities. On one hand, there is no standardized approach to reporting disasters with regard to the duration and spatial extend as well as the documentation of loss and damage due to disaster impacts. As a result, the ability to make accurate comparisons at the global, regional and national level is relatively limited (WMO, 2021). On the other hand, the general availability of disaster mortality data varies widely across the globe, with considerable differences with regard to the quality and completeness of data sources (Saulnier et al., 2019). Additionally, it is important to recognize that the reporting of fatalities from natural disasters can be politically influenced. There have been occasions where the number of fatalities from disasters has been officially reported to be lower than assessed by other parties, such as independent researchers (Guha-Sapir & Checchi, 2018). As Guha-Sapir and Checchi (2018) note, "high death tolls indicate the severity of a natural disaster but can also point to politically damaging inadequacies in the relief effort and to underlying poverty and inequality in the affected population" (Guha-Sapir & Checchi, 2018, p. 1).

Project Funding Analysis

Other uncertainties and limitations of this study are related to the methodological approach chosen to analyse the project funding. The main limitation is that, as already mentioned, the amounts of project funding for each climate-related hazard have generally been significantly overestimated. Regarding the GCF, generally for all projects, the total amount of funding was included, even if certain project components were not focused on disaster risk reduction. Although an attempt has been made to take this into account to some extent by distinguishing between projects with a minor and main focus on disaster risk reduction, this still results in an overestimation of funding. Furthermore, for projects addressing several climate-related hazards simultaneously, the total amount of funding was allocated to each climate-related hazard, leading to another substantial overestimation.

Another aspect to note is that not all GCF Funding Proposals and AF Project Documents were fully read to determine whether the projects could be used for further analysis (see Methodology). This leaves open the possibility of misclassifications. In addition, when analysing GCF Funding Proposals and AF Project Documents about projects concerned with flooding, it was sometimes difficult to determine whether they were addressing riverine floods or flash floods, as they were often referred to as floods in general. In cases where it was unclear, an attempt was made to determine this from the context. In some instances, it appeared that projects were tackling both types of flooding at the same time, which ultimately contributes to an additional overestimation of the amount of funding provided for riverine flood projects.

6. Conclusion

Given the increasing risk of climate-related disasters, driven in part by climate change, adaptation strategies and measures are becoming more important due to their potential to save lives and, more generally, to promote sustainable development, particularly in developing countries and mountainous regions. The main focus of this Master's thesis was on analysing whether current adaptation strategies and measures are efficient in terms of addressing the climate-related hazards that cause the most fatalities. In the context of investigating this issue, the following research questions were answered:

What climate-related hazards represent the greatest risk, defined by the highest number of fatalities, to developing countries and specifically High Mountain Asia countries?

- On a global scale, riverine floods pose the highest risk in terms of fatalities, followed by landslides and GLOFs.
- When looking at HMA countries, riverine floods account for the most fatalities, followed by landslides, GLOFs and snow avalanches. However, when the annual fatality results are taken into account, it appears that snow avalanches are actually deadlier than GLOFs.

How is adaptation funding, provided by the GCF and the AF allocated among adaptation projects targeting specific climate-related hazards?

- At the global level, adaptation funding was allocated in the following priority order:
    - GCF: Riverine floods received the most funding, followed by landslides, snow avalanches and GLOFs.
    - AF: Most of the funding went to riverine floods, then landslides and finally GLOFs. No funding was allocated to snow avalanches.
    - GCF and AF: Funding was primarily invested in riverine floods, followed by landslides, GLOFs and snow avalanches.
- Taking into account the fact that the funding amounts have been partially overestimated, snow avalanches may actually receive less funding than GLOFs when GCF funding is considered. However, when looking at AF and the combined GCF and AF funding volumes, the above ranking of funding volumes is appropriate.
- Looking at High Mountain Asia countries, funding was allocated in the following order:
    - GCF: Most of the funding was targeted at riverine floods, followed by landslides, GLOFs and snow avalanches.
    - AF: GLOFs were addressed the most, followed by riverine floods, while no funding was provided for landslides and snow avalanches.
    - GCF and AF: The largest amount of funding was allocated to riverine floods, then landslides, GLOFs and finally snow avalanches.
- The overestimation of funding only affects the ratio of funding for each type of hazard, not the order in which the four climate-related hazards are ranked.

How do the societal impacts (fatalities) from climate-related hazards assessed in the course of this Master's thesis align to the distribution of adaptation funding?

- At the global level, funding per fatality is only aligned with the lethality of the hazard when GCF funding alone and combined GCF and AF funding are considered. AF funding alone does not reflect this alignment, as funding per fatality for riverine floods is too low compared to GLOFs.
- In High Mountain Asia countries, funding per fatality levels do not match the lethality of the hazards, whether the GCF, the AF or both funds are examined. Riverine floods are generally underfunded in relation to their fatality rates compared to landslides and GLOFs. In addition, if snow

avalanches are perceived as a greater risk than GLOFs, then the funding per fatality allocated to snow avalanches is generally insufficient compared to that for GLOFs.

What other factors influence the allocation of adaptation funding?

- The research identified a number of factors that may influence the distribution of adaptation funding:
    - GCF and AF funding allocation criteria
    - Political factors
    - Economic impacts of climate-related disasters
    - Perception of climate change and hazard connections
    - Perception of spatial and temporal hazard characteristics
    - Disaster-driven funding allocation

In conclusion, based on the research conducted in the context of this Master's thesis, current adaptation projects funded by the GCF and the AF are only partially efficient in the sense that they address those climate-related hazards that pose the greatest risk, i.e. cause the most fatalities. The results reflect that the allocation of adaptation funding is not only determined by the number of fatalities caused by a hazard, but also by several other factors. This highlights the complexity in allocating financial resources in the context of CCA, with the consequence that funding is not always directly aligned with the hazards that cause the most fatalities.

In order to increase the effectiveness of adaptation funding in addressing the deadliest hazards, a more balanced approach can be recommended, with greater emphasis the societal impacts of hazards, while preserving the integrity of other GCF and AF priorities and maintaining a country-driven approach. This could be particularly beneficial for effectively addressing hazards such as snow avalanches, which this research has identified as underfunded relative to other hazard types. However, this would also require improved availability and accuracy of fatality data across all hazard types, particularly snow avalanches. This is necessary to adequately assess and understand the societal impact of hazards, which is essential to justify funding allocations and to ensure transparency in the decision-making process. In addition, more research is recommended to develop a better understanding of how climate change affects hazards and thus disaster risk. Once again, this is particularly important in the context of snow avalanches, as this could reshape the perception of this hazard and ultimately contribute to increased funding.

While this Master's thesis has analysed two of the largest funds within the climate finance mechanism, providing a solid overview of funding allocation, future research could benefit from examining the distribution of financial resources provided by other components of both UNFCCC and non-UNFCCC finance mechanisms. Furthermore, the integration of artificial intelligence (AI) offers an opportunity to refine and improve the analysis, particularly in addressing the limitation in this study of not being able to review all project documents in detail due to time constraints. By taking a more comprehensive approach to examining the allocation of adaptation funding, including the use of AI, future research could provide a more accurate and detailed understanding of how resources are distributed across hazards, ultimately helping to develop sustainable solutions that ensure funds are invested in the most effective way.

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Appendices

Appendix A: Raw Data

Table 18: *Raw data on fatalities from riverine floods, landslides and GLOFs globally for non-Annex I countries (1950-2023), and from riverine floods, landslides, GLOFs and snow avalanches in HMA (1972-2023).*

	Global Fatalities (Non-Annex I Countries)			Fatalities in High Mountain Asia			
Year	Riverine Floods	Landslides	GLOFs	Riverine Floods	Landslides	GLOFs	Snow Avalanches
1950	2945	130	0	-	-	-	-
1951	0	0	0	-	-	-	-
1952	0	28	0	-	-	-	-
1953	0	0	151	-	-	-	-
1954	0	876	691	-	-	-	-
1955	0	481	0	-	-	-	-
1956	0	236	10	-	-	-	-
1957	0	0	0	-	-	-	-
1958	35	52	0	-	-	-	-
1959	0	0	0	-	-	-	-
1960	0	52	0	-	-	-	-
1961	0	166	0	-	-	-	-
1962	0	2071	0	-	-	-	-
1963	0	2183	52	-	-	-	-
1964	0	108	0	-	-	-	-
1965	63	140	0	-	-	-	-
1966	575	604	0	-	-	-	-
1967	0	590	0	-	-	-	-
1968	276	1176	0	-	-	-	-
1969	0	18	0	-	-	-	-
1970	37	84	0	-	-	-	-
1971	527	1020	13	-	-	-	-
1972	672	755	0	0	105	0	17
1973	9	3541	50	0	0	0	2
1974	0	877	0	0	0	1	0
1975	0	182	0	0	125	1	2
1976	0	315	0	0	150	0	0
1977	526	40	2	500	0	20	0
1978	95	86	0	17	64	0	30
1979	0	338	0	0	272	0	237
1980	106	290	0	0	150	0	10
1981	152	401	200	0	0	200	0
1982	0	671	0	0	94	0	0
1983	118	1235	0	100	365	0	0
1984	3	191	0	0	100	0	0
1985	1073	610	0	723	60	5	0
1986	897	423	0	191	88	0	0
1987	4531	916	0	3454	65	0	0
1988	3846	592	10	1884	307	25	42
1989	2339	421	0	1809	139	0	20
1990	1811	136	0	837	103	0	0
1991	5052	415	0	4244	0	10	0
1992	2760	428	0	2433	353	1	0
1993	1803	868	0	676	168	0	0
1994	3644	277	21	1958	210	25	0
1995	5949	1076	0	4215	916	0	48
1996	5952	599	0	4775	297	0	0
1997	4878	361	0	1602	260	0	69
1998	5377	860	102	4911	463	102	11
1999	1774	243	0	1268	23	0	0
2000	4353	528	0	2068	272	0	0
2001	2598	770	0	542	426	0	0
2002	2544	775	23	996	535	25	0
2003	2847	610	0	1646	102	0	0
2004	6387	256	0	2540	103	0	0
2005	4673	347	0	3539	12	0	570
2006	3643	1605	1	1891	221	0	18
2007	7479	192	1	4823	133	0	18
2008	2398	514	3	1015	361	3	16
2009	3396	631	2	1954	268	2	16
2010	5466	3175	1980	2848	2222	0	300
2011	5827	309	0	1913	86	0	0
2012	3327	244	0	1767	37	0	351
2013	9597	281	6005	7467	181	6010	0
2014	2144	944	0	1382	342	0	61
2015	1703	712	32	676	165	0	691
2016	985	281	0	290	67	0	35
2017	388	448	3	86	175	4	187
2018	21	198	12	11	0	10	11
2019	89	651	0	0	93	0	8
2020	54	382	13	0	111	0	93
2021	30	120	0	0	68	25	22
2022	3	372	0	0	102	0	33
2023	2	620	0	0	71	0	0

Table 19: *Raw data for the regional analysis of fatalities from riverine floods, landslides and GLOFs (1950-2023).*

	Fatalities in Africa			Fatalities in Asia-Pacific			Fatalities in Latin America and the Caribbean			Fatalities in Eastern Europe		
Year	**Riverine Floods**	**Landslides**	**GLOFs**	**Riverine Floods**	**Landslides**	**GLOFs**	**Riverine Floods**	**Landslides**	**GLOFs**	**Riverine Floods**	**Landslides**	**GLOFs**
1950	0	0	0	2945	0	0	0	130	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	30	691	0	549	0	0	0	0
1955	0	0	0	0	405	0	0	0	0	0	0	0
1956	0	0	0	0	130	10	0	66	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	52	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	40	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	2071	0	0	0	0
1963	0	0	0	0	266	52	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	60	103	0	0	0	0
1966	0	0	0	513	0	0	62	400	0	0	0	0
1967	0	154	0	0	0	0	0	436	0	0	0	0
1968	0	154	0	276	1000	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	18	0	0	0	0
1970	0	0	0	0	84	0	0	0	0	0	0	0
1971	500	0	0	0	200	13	0	820	0	0	0	0
1972	0	0	0	672	105	0	0	70	0	0	0	0
1973	0	0	0	0	0	50	9	3541	0	0	0	0
1974	0	0	0	0	27	0	0	821	0	0	0	0
1975	0	0	0	0	125	0	0	0	0	0	0	0
1976	0	0	0	0	175	0	0	73	0	0	0	0
1977	0	0	0	500	27	2	0	0	0	0	0	0
1978	0	0	0	91	86	0	0	0	0	0	0	0
1979	0	0	0	0	308	0	0	30	0	0	0	0
1980	0	0	0	0	250	0	100	0	0	0	0	0
1981	0	0	0	0	200	200	150	135	0	0	0	0
1982	0	47	0	0	369	0	0	230	0	0	0	0
1983	0	0	0	100	406	0	0	759	0	0	0	0
1984	0	0	0	3	147	0	0	30	0	0	0	0
1985	17	0	0	880	360	0	137	150	0	0	0	0
1986	0	0	0	694	88	0	203	301	0	0	0	0
1987	506	0	0	3654	196	0	366	653	0	0	0	0
1988	388	0	0	2754	506	10	671	22	0	0	0	0
1989	17	0	0	2197	244	0	105	61	0	0	0	0
1990	309	0	0	1248	103	0	122	33	0	0	0	0
1991	49	13	0	4827	233	0	56	119	0	0	0	0
1992	21	0	0	2575	428	0	135	0	0	0	0	0
1993	57	15	0	1259	326	0	234	470	0	0	0	0
1994	987	22	0	2357	237	21	66	18	0	47	0	0
1995	935	0	0	4906	936	0	93	123	0	1	0	0
1996	251	34	0	5571	422	0	42	120	0	0	0	0
1997	2817	20	0	1661	260	0	127	12	0	7	0	0
1998	153	87	0	5054	463	102	0	137	0	0	0	0
1999	223	0	0	1414	156	0	7	87	0	0	0	0
2000	1042	49	0	3076	408	0	201	32	0	0	6	0
2001	1075	36	0	1287	611	0	156	114	0	0	0	0
2002	415	16	0	1625	696	23	284	60	0	1	0	0
2003	371	20	0	1920	489	0	506	101	0	2	0	0
2004	100	0	0	2694	256	0	3542	0	0	2	0	0
2005	160	0	0	3820	262	0	471	70	0	3	0	0

2006	892	24	0	2368	1556	0	238	21	0	0	0	0
2007	764	0	0	6065	176	0	512	16	0	0	0	0
2008	328	10	0	1400	416	3	551	88	0	3	0	0
2009	634	27	0	2333	374	2	340	182	0	0	0	0
2010	607	490	0	3432	2305	1980	1224	367	0	9	0	0
2011	672	0	0	3464	243	0	1648	63	0	0	0	0
2012	852	18	0	2179	204	0	207	22	0	0	0	0
2013	720	0	0	8366	231	6005	411	43	0	1	0	0
2014	235	11	0	1600	710	0	180	98	0	78	0	0
2015	689	18	0	894	236	32	85	458	0	0	0	0
2016	36	65	0	873	206	0	72	10	0	0	0	0
2017	89	180	0	221	215	0	36	53	0	0	0	0
2018	5	79	0	11	80	12	0	15	0	0	0	0
2019	53	411	0	0	205	0	24	34	0	0	0	0
2020	37	22	0	5	329	0	11	18	13	0	0	0
2021	16	0	0	3	100	0	10	20	0	0	0	0
2022	0	38	0	0	140	0	3	194	0	0	0	0
2023	0	191	0	0	170	0	0	241	0	2	18	0

Table 20: *Raw data for the analysis of riverine flood fatalities in the countries of HMA (1972-2023).*

Year	Afghanistan	Bangladesh	Bhutan	China	India	Kazakhstan	Kyrgyzstan	Nepal	Pakistan	Tajikistan	Uzbekistan
1972	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	500	0	0	0	0	0	0
1978	0	17	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	100	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0
1985	0	7	0	64	652	0	0	0	0	0	0
1986	0	4	0	0	187	0	0	0	0	0	0
1987	0	2055	0	199	1200	0	0	0	0	0	0
1988	0	61	0	350	1250	0	0	27	196	0	0
1989	0	180	0	0	1609	0	0	0	20	0	0
1990	0	231	0	495	81	0	0	30	0	0	0
1991	1193	265	0	1835	927	0	0	0	24	0	0
1992	0	17	0	515	567	0	0	0	1334	0	0
1993	0	190	0	41	435	10	0	0	0	0	0
1994	0	64	0	1564	14	0	0	0	316	0	0
1995	10	441	0	1498	1514	0	0	140	612	0	0
1996	70	55	0	3975	544	0	0	20	111	0	0
1997	70	0	0	1090	271	0	0	0	171	0	0
1998	0	1050	0	3760	0	0	0	50	0	51	0
1999	0	48	0	725	325	0	0	170	0	0	0
2000	0	0	200	117	1751	0	0	0	0	0	0
2001	0	9	0	342	191	0	0	0	0	0	0
2002	46	0	0	205	715	0	0	0	22	8	0
2003	63	187	0	662	259	0	0	239	230	6	0
2004	16	750	0	429	1155	0	0	185	5	0	0
2005	283	23	0	453	2102	0	3	51	616	8	0
2006	85	0	0	330	1116	0	0	0	360	0	0
2007	227	1230	0	967	1804	0	0	214	380	1	0

2008	0	28	0	352	436	1	0	115	83	0	0
2009	50	16	0	209	1489	0	0	117	52	21	0
2010	135	15	0	1911	494	0	0	150	68	75	0
2011	62	0	0	628	608	2	0	104	509	0	0
2012	149	139	0	622	279	0	0	72	506	0	0
2013	113	0	0	637	6373	0	0	76	268	0	0
2014	0	59	0	422	622	0	0	24	255	0	0
2015	0	31	0	156	439	0	0	0	50	0	0
2016	0	106	0	43	0	0	0	0	141	0	0
2017	0	0	0	11	75	0	0	0	0	0	0
2018	0	0	0	11	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0
2023	0	0	0	0	0	0	0	0	0	0	0

Table 21: *Raw data for the analysis of landslide fatalities in the countries of HMA (1972-2023).*

Year	Afghanistan	Bangladesh	Bhutan	China	India	Kazakhstan	Kyrgyzstan	Nepal	Pakistan	Tajikistan	Uzbekistan
1972	0	0	0	0	0	0	0	105	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	125	0	0	0
1976	0	0	0	0	0	0	0	150	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	64	0	0	0	0	0	0
1979	0	0	0	0	272	0	0	0	0	0	0
1980	0	0	0	0	150	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	94	0	0	0	0	0	0	0
1983	0	0	0	277	67	0	0	21	0	0	0
1984	0	0	0	100	0	0	0	0	0	0	0
1985	0	0	0	60	0	0	0	0	0	0	0
1986	0	0	0	0	88	0	0	0	0	0	0
1987	0	0	0	65	0	0	0	0	0	0	0
1988	0	0	0	52	255	0	0	0	0	0	0
1989	0	0	0	4	86	0	0	49	0	0	0
1990	0	0	0	73	30	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	49	60	0	0	0	0	243	1
1993	0	0	0	120	20	0	0	28	0	0	0
1994	0	0	0	48	0	0	162	0	0	0	0
1995	354	0	0	37	440	0	0	85	0	0	0
1996	0	0	0	249	48	0	0	0	0	0	0
1997	0	0	0	189	51	0	0	20	0	0	0
1998	0	0	0	100	350	0	0	0	13	0	0
1999	0	0	0	23	0	0	0	0	0	0	0
2000	0	0	0	85	187	0	0	0	0	0	0
2001	0	0	0	168	98	0	0	144	15	1	0
2002	0	0	0	63	0	0	0	472	0	0	0
2003	0	0	0	52	0	0	38	0	12	0	0
2004	0	0	0	65	0	0	38	0	0	0	0
2005	0	0	0	0	12	0	0	0	0	0	0
2006	13	0	0	22	0	0	0	157	29	0	0
2007	0	0	0	33	0	0	0	0	100	0	0
2008	0	13	0	311	37	0	0	0	0	0	0
2009	0	0	0	203	55	0	0	10	0	0	0

2010	0	66	0	2137	0	0	0	0	19	0	0
2011	0	17	0	40	0	0	0	29	0	0	0
2012	0	0	0	19	0	0	0	0	18	0	0
2013	24	0	0	157	0	0	0	0	0	0	0
2014	0	0	0	35	151	0	0	156	0	0	0
2015	52	7	0	38	3	0	0	65	0	0	0
2016	0	0	0	57	10	0	0	0	0	0	0
2017	0	0	0	72	68	0	24	11	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0
2019	40	2	0	51	0	0	0	0	0	0	0
2020	0	0	0	4	91	0	0	0	16	0	0
2021	0	0	0	0	68	0	0	0	0	0	0
2022	0	0	0	13	67	0	0	22	0	0	0

Table 22: *Raw data for the analysis of GLOF fatalities in the countries of HMA (1972-2023).*

Year	Afghanistan	Bangladesh	Bhutan	China	India	Kazakhstan	Kyrgyzstan	Nepal	Pakistan	Tajikistan	Uzbekistan
1972	0	n/a	0	0	0	0	0	0	0	0	0
1973	0	n/a	0	0	0	0	0	0	0	0	0
1974	0	n/a	0	0	0	0	0	0	1	0	0
1975	0	n/a	0	0	0	0	0	0	1	0	0
1976	0	n/a	0	0	0	0	0	0	0	0	0
1977	0	n/a	0	0	0	20	0	0	0	0	0
1978	0	n/a	0	0	0	0	0	0	0	0	0
1979	0	n/a	0	0	0	0	0	0	0	0	0
1980	0	n/a	0	0	0	0	0	0	0	0	0
1981	0	n/a	0	200	0	0	0	0	0	0	0
1982	0	n/a	0	0	0	0	0	0	0	0	0
1983	0	n/a	0	0	0	0	0	0	0	0	0
1984	0	n/a	0	0	0	0	0	0	0	0	0
1985	0	n/a	0	0	0	0	0	5	0	0	0
1986	0	n/a	0	0	0	0	0	0	0	0	0
1987	0	n/a	0	0	0	0	0	0	0	0	0
1988	0	n/a	0	5	0	0	0	20	0	0	0
1989	0	n/a	0	0	0	0	0	0	0	0	0
1990	0	n/a	0	0	0	0	0	0	0	0	0
1991	0	n/a	0	10	0	0	0	0	0	0	0
1992	0	n/a	0	0	0	0	0	0	1	0	0
1993	0	n/a	0	0	0	0	0	0	0	0	0
1994	0	n/a	20	0	0	0	0	0	5	0	0
1995	0	n/a	0	0	0	0	0	0	0	0	0
1996	0	n/a	0	0	0	0	0	0	0	0	0
1997	0	n/a	0	0	0	0	0	0	0	0	0
1998	0	n/a	0	0	0	0	100	2	0	0	0
1999	0	n/a	0	0	0	0	0	0	0	0	0
2000	0	n/a	0	0	0	0	0	0	0	0	0
2001	0	n/a	0	0	0	0	0	0	0	0	0
2002	0	n/a	0	0	0	0	0	0	0	25	0
2003	0	n/a	0	0	0	0	0	0	0	0	0
2004	0	n/a	0	0	0	0	0	0	0	0	0
2005	0	n/a	0	0	0	0	0	0	0	0	0
2006	0	n/a	0	0	0	0	0	0	0	0	0
2007	0	n/a	0	0	0	0	0	0	0	0	0
2008	0	n/a	0	0	0	0	3	0	0	0	0
2009	0	n/a	0	2	0	0	0	0	0	0	0
2010	0	n/a	0	0	0	0	0	0	0	0	0
2011	0	n/a	0	0	0	0	0	0	0	0	0
2012	0	n/a	0	0	0	0	0	0	0	0	0

2013	5	n/a	0	5	6000	0	0	0	0	0	0
2014	0	n/a	0	0	0	0	0	0	0	0	0
2015	0	n/a	0	0	0	0	0	0	0	0	0
2016	0	n/a	0	0	0	0	0	0	0	0	0
2017	0	n/a	0	0	4	0	0	0	0	0	0
2018	10	n/a	0	0	0	0	0	0	0	0	0
2019	0	n/a	0	0	0	0	0	0	0	0	0
2020	0	n/a	0	0	0	0	0	0	0	0	0
2021	0	n/a	0	0	0	0	0	25	0	0	0
2022	0	n/a	0	0	0	0	0	0	0	0	0
2023	0	n/a	0	0	0	0	0	0	0	0	0

Table 23: *Raw data for the analysis of snow avalanche fatalities in the countries of HMA (1972-2023).*

Year	**Afghanistan**	**Bangladesh**	**Bhutan**	**China**	**India**	**Kazakhstan**	**Kyrgyzstan**	**Nepal**	**Pakistan**	**Tajikistan**	**Uzbekistan**
1972	0	n/a	n/a	0	2	0	0	15	0	0	0
1973	0	n/a	n/a	0	2	0	0	0	0	0	0
1974	0	n/a	n/a	0	0	0	0	0	0	0	0
1975	0	n/a	n/a	0	2	0	0	0	0	0	0
1976	0	n/a	n/a	0	0	0	0	0	0	0	0
1977	0	n/a	n/a	0	0	0	0	0	0	0	0
1978	0	n/a	n/a	0	30	0	0	0	0	0	0
1979	0	n/a	n/a	0	237	0	0	0	0	0	0
1980	0	n/a	n/a	0	0	0	0	10	0	0	0
1981	0	n/a	n/a	0	0	0	0	0	0	0	0
1982	0	n/a	n/a	0	0	0	0	0	0	0	0
1983	0	n/a	n/a	0	0	0	0	0	0	0	0
1984	0	n/a	n/a	0	0	0	0	0	0	0	0
1985	0	n/a	n/a	0	0	0	0	0	0	0	0
1986	0	n/a	n/a	0	0	0	0	0	0	0	0
1987	0	n/a	n/a	0	0	0	0	0	0	0	0
1988	0	n/a	n/a	0	0	0	0	0	42	0	0
1989	0	n/a	n/a	0	0	0	0	20	0	0	0
1990	0	n/a	n/a	0	0	0	0	0	0	0	0
1991	0	n/a	n/a	0	0	0	0	0	0	0	0
1992	0	n/a	n/a	0	0	0	0	0	0	0	0
1993	0	n/a	n/a	0	0	0	0	0	0	0	0
1994	0	n/a	n/a	0	0	0	0	0	0	0	0
1995	0	n/a	n/a	0	0	0	0	48	0	0	0
1996	0	n/a	n/a	0	0	0	0	0	0	0	0
1997	0	n/a	n/a	0	4	0	0	19	0	46	0
1998	0	n/a	n/a	0	11	0	0	0	0	0	0
1999	0	n/a	n/a	0	0	0	0	0	0	0	0
2000	0	n/a	n/a	0	0	0	0	0	0	0	0
2001	0	n/a	n/a	0	0	0	0	0	0	0	0
2002	0	n/a	n/a	0	0	0	0	0	0	0	0
2003	0	n/a	n/a	0	0	0	0	0	0	0	0
2004	0	n/a	n/a	0	0	0	0	0	0	0	0
2005	0	n/a	n/a	0	540	0	0	21	0	9	0
2006	0	n/a	n/a	0	0	6	0	0	0	12	0
2007	0	n/a	n/a	0	0	0	0	2	0	16	0
2008	0	n/a	n/a	16	0	0	0	0	0	0	0
2009	10	n/a	n/a	0	0	0	0	0	0	6	0
2010	172	n/a	n/a	0	0	0	0	0	120	8	0
2011	0	n/a	n/a	0	0	0	0	0	0	0	0
2012	201	n/a	n/a	10	0	0	0	0	140	0	0
2013	0	n/a	n/a	0	0	0	0	0	0	0	0
2014	0	n/a	n/a	0	0	0	0	61	0	0	0

2015	310	n/a	n/a	0	0	0	0	373	0	8	0
2016	0	n/a	n/a	9	10	0	0	16	0	0	0
2017	137	n/a	n/a	0	26	7	3	2	0	12	0
2018	0	n/a	n/a	0	11	0	0	0	0	0	0
2019	0	n/a	n/a	0	6	0	0	2	0	0	0
2020	21	n/a	n/a	0	10	0	0	7	55	0	0
2021	14	n/a	n/a	0	8	0	0	0	0	0	0
2022	19	n/a	n/a	0	7	3	3	1	0	0	0
2023	0	n/a	n/a	0	0	0	0	0	0	0	0

Table 24: *GCF projects classified as "usable" in the context of this Master's thesis research.*

Project Title	Region	Countries	Theme	Total Funding (USD)	Concept Note Receipt Date	Funding Proposal Receipt Date	Type of Hazard	DRR Focus
Scaling up the use of Modernized Climate information and Early Warning Systems in Malawi	Africa	Malawi	Adaptation	12295000	31.03.2015	29.07.2015	Riverine Floods	Main Focus
Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project	Africa	Mali	Adaptation	22750000	n/a	31.0.2015	Riverine Floods	Main Focus
Scaling-up of Glacial Lake Outburst Flood (GLOF) risk reduction in Northern Pakistan	Asia-Pacific	Pakistan	Adaptation	36960000	30.05.2015	31.07.2015	GLOFs	Main Focus
Building Resilient Communities, Wetland Ecosystems and Associated Catchments in Uganda	Africa	Uganda	Adaptation	24140000	29.06.2015	30.07.2015	Riverine Floods	Minor Focus
Climate Information Services for Resilient Development Planning in Vanuatu (Van-CIS-RDP)	Asia-Pacific	Vanuatu	Adaptation	22953000	02.06.2015	23.07.2015	Riverine Floods	Minor Focus
Integrated Flood Management to Enhance Climate Resilience of the Vaisigano River Catchment in Samoa	Asia-Pacific	Samoa	Adaptation	57718000	30.08.2016	23.09.2016	Riverine Floods	Main Focus
Implementation Project of the Integral Management Plan of the Lujan River Basin	Latin America and the Caribbean	Argentina	Adaptation	58528147	n/a	20.08.2016	Riverine Floods	Main Focus
Scaling up climate resilient water management practices for vulnerable communities in La Mojana	Latin America and the Caribbean	Colombia	Adaptation	38496000	n/a	05.03.2017	Riverine Floods	Minor Focus
Scaling-up Multi-Hazard Early Warning System and the Use of Climate Information in Georgia	Eastern Europe	Georgia	Adaptation	27053598	23.11.2016	06.06.2017	Riverine Floods, Landslides, Snow Avalanches	Main Focus
Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Burkina Faso Country Project	Africa	Burkina Faso	Adaptation	22500000	n/a	13.10.2016	Riverine Floods	Main Focus
Institutional Development of the State Agency for Hydrometeorology of Tajikistan	Asia-Pacific	Tajikistan	Adaptation	5000000	07.06.2017	16.10.2017	Riverine Floods, Landslides	Minor Focus
Safeguarding rural communities and their physical and economic assets from climate induced disasters in Timor-Leste	Asia-Pacific	Timor-Leste	Adaptation	22356805	23.06.201	24.06.2018	Riverine Floods, Landslides	Minor Focus
Building Regional Resilience through Strengthened Meteorological, Hydrological and Climate Services in the Indian Ocean Commission (IOC) Member Countries	Africa	Comoros (the), Madagascar, Mauritius, Seychelles	Adaptation	52767986	27.07.2018	30.04.2020	Riverine Floods, Landslides	Main Focus
Enhancing Early Warning Systems to build greater resilience to hydro-meteorological hazards in Timor-Leste	Asia-Pacific	Timor-Leste	Adaptation	20980722.33	05.09.2019	12.08.2020	Riverine Floods, Landslides	Main Focus
Enhancing community resilience and water security in the Upper Athi River Catchment Area, Kenya	Africa	Kenya	Adaptation	9526603.26	n/a	03.11.2016	Riverine Floods	Minor Focus
Recharge Pakistan: Building Pakistan's resilience to climate change through Ecosystem-based Adaptation (EbA) and Green Infrastructure for integrated flood risk management	Asia-Pacific	Pakistan	Adaptation	66000005	19.08.2019	03.12.2022	Riverine Floods, Landslides	Minor Focus
Community Resilience Partnership Program	Asia-Pacific	Cambodia, Indonesia, Lao People's Democratic Republic (the), Pakistan, Papua New Guinea, Timor-Leste, Vanuatu	Adaptation	120000000	05.08.2020	20.12.2020	Riverine Floods, Landslides	Minor Focus
Scaling up climate resilient flood risk management in Bosnia and Herzegovina	Eastern Europe	Bosnia and Herzegovina	Adaptation	14400000	31.05.2019	06.07.2021	Riverine Floods	Main Focus
Improving rangeland and ecosystem management practices of smallholder farmers under conditions of climate change in Sesfontein, Fransfontein, and Warmquelle areas of the Republic of Namibia	Africa	Namibia	Adaptation	9300000	17.11.2017	20.12.2017	Riverine Floods	Minor Focus
Climate services and diversification of climate sensitive livelihoods to empower food insecure and vulnerable communities in the Kyrgyz Republic	Asia-Pacific	Kyrgyzstan	Adaptation	8576108	15.06.2015	22.03.2017	Riverine Floods, Landslides, Snow Avalanches	Minor Focus
Extended Community Climate Change Project-Flood (ECCP-Flood)	Asia-Pacific	Bangladesh	Adaptation	9681340	24.12.2017	25.06.2018	Riverine Floods	Minor Focus
Multi-Hazard Impact-Based Forecasting and Early Warning System for the Philippines	Asia-Pacific	Philippines (the)	Adaptation	9999042.27	05.03.2019	08.03.2019	Riverine Floods, Landslides	Main Focus
Enhancing Climate Information Systems for Resilient Development in Liberia (Liberia CIS)	Africa	Liberia	Adaptation	10000000	30.01.2020	04.02.2020	Riverine Floods	Main Focus

Enhancing Multi-Hazard Early Warning System to increase resilience of Uzbekistan communities to climate change induced hazards	Asia-Pacific	Uzbekistan	Adaptation	9999455	16.07.2019	25.01.2020	Riverine Floods, Landslides, Snow Avalanches	Main Focus
Solomon Islands Knowledge-Action-Sustainability for Resilient Villages (SOLKAS) Project	Asia-Pacific	Solomon Islands	Adaptation	24965114	23.12.2020	11.11.2022	Riverine Floods	Minor Focus
Enhancing Climate Information Systems for Resilient Development in Sierra Leone	Africa	Sierra Leone	Adaptation	15094264	30.04.2022	20.02.2023	Riverine Floods, Landslides	Main Focus
Strengthening Climate Resilience of Rural Communities in Northern Rwanda	Africa	Rwanda	Cross-cutting	32794442	03.06.2015	30.07.2015	Riverine Floods, Landslides	Minor Focus
Programme for integrated development and adaptation to climate change in the Niger Basin (PIDACC/NB)	Africa	Benin, Burkina Faso, Cameroon, Chad, Côted'Ivoire, Guinea, Mali, Niger (the), Nigeria	Cross-cutting	6774000	n/a	08.06.2017	Riverine Floods	Minor Focus
Improving Climate Resilience of Vulnerable Communities and Ecosystems in the Gandaki River Basin, Nepal	Asia-Pacific	Nepal	Cross-cutting	27404139	25.02.2018	22.06.2018	Riverine Floods, Landslides	Minor Focus
The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW)	Africa	Burkina Faso, Chad, Gambia, Mali, Mauritania, Niger (the), Senegal	Cross-cutting	82849900	n/a	12.12.2018	Riverine Floods	Minor Focus
Ouémé Basin Climate-Resilience Initiative (OCRI) Benin	Africa	Benin	Cross-cutting	18453795	21.12.2017	30.03.2021	Riverine Floods	Minor Focus
Heritage Colombia (HECO): Maximizing the Contributions of Sustainably Managed Landscapes in Colombia for Achievement of Climate Goals	Latin America and the Caribbean	Colombia	Cross-cutting	42974559	20.10.2019	13.08.2021	Riverine Floods, Landslides	Minor Focus
Building Resilience of Vulnerable Communities to Climate Variability in Rwanda's Congo Nile Divide through Forest and Landscape Restoration	Africa	Rwanda	Cross-cutting	39056421	11.12.2018	25.02.2022	Landslides	Minor Focus

Table 25: *AF projects classified as "usable" in the context of this Master's thesis research.*

Project Title	**Region**	**Countries**	**Sector**	**Total Funding (USD)**	**Project Approval Date**	**Type of Hazard**
Implementing Measures for Climate Change Adaptation and Disaster Risk Reduction Mitigation of School Fatalities	Latin America and the Caribbean	Haiti	Disaster Risk Reduction	9916344	23.02.2022	Riverine Floods, Landslides
Adaptation Initiative for Climate Vulnerable Offshore Small Islands and Riverine Charland in Bangladesh	Asia-Pacific	Bangladesh	Disaster Risk Reduction	9995369	15.03.2019	Riverine Floods
Flood Resilience in Ulaanbaatar Ger Areas - Climate Change Adaptation through community-driven small-scale protective and basic-services interventions	Asia-Pacific	Mongolia	Disaster Risk Reduction	4495235	16.07.2018	Riverine Floods
Enhancing adaptive capacity of communities to climate change-related floods in the North Coast and Islands Region of Papua New Guinea	Asia-Pacific	Papua New Guinea	Disaster Risk Reduction	6530373	16.03.2012	Riverine Floods, Landslides
Reducing Risk and Vulnerability to Climate Change in the Region of La Depresion Momposina in Colombia	Latin America and the Caribbean	Colombia	Disaster Risk Reduction	8518307	29.06.2012	Riverine Floods, Landslides
Reducing Risks and Vulnerabilities from Glacier Lake Outburst Floods in Northern Pakistan	Asia-Pacific	Pakistan	Disaster Risk Reduction	3906000	15.12.2010	GLOFs
Reducing vulnerabilities of populations in the Central Asia region from glacier lake outburst floods in a changing climate	Asia-Pacific	Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan	Disaster Risk Reduction and Early Warning System	6500000	15.10.2020	GLOFs
Enhancing Adaptive Capacity of Andean Communities through Climate Services (ENANDES)	Latin America and the Caribbean	Chile, Colombia, Peru	Disaster Risk Reduction and Early Warning System	7432250	07.08.2019	Landslides
Building urban climate resilience in south-eastern Africa	Africa	Madagascar, Malawi, Mozambique, Union of Comoros	Disaster Risk Reduction and Early Warning System	13997423	15.07.2019	Riverine Floods, Landslides
Integrated climate-resilient transboundary flood risk management in the Drin River basin in the Western Balkans	Eastern Europe	Albania, the Former Yugoslav Republic of Macedonia, Montenegro	Disaster Risk Reduction and Early Warning System	9927750	15.03.2019	Riverine Floods, Landslides
Integration of climate change adaptation measures in the concerted management of the WAP transboundary complex: ADAPT-WAP	Africa	Benin, Burkina Faso, Niger	Disaster Risk Reduction and Early Warning System	11536200	15.07.2019	Riverine Floods
Climate change adaptation in vulnerable coastal cities and ecosystems of the Uruguay River	Latin America and the Caribbean	Argentina, Uruguay	Disaster Risk Reduction and Early Warning System	13999996	15.07.2019	Riverine Floods
Integrating Flood and Drought Management and Early Warning for Climate Chane Adaptation in the Volta Basin	Africa	Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Togo	Disaster Risk Reduction and Early Warning System	7920000	10.12.2018	Riverine Floods
Reducing climate vulnerability and flood risk in coastal urban and semi urban areas in cities in Latin America	Latin America and the Caribbean	Chile, Ecuador	Disaster Risk Reduction and Early Warning System	13910400	16.07.2018	Riverine Floods, Landslides
Multisectoral Adaptation Measures to Climate Change in the South Oropouche River Basin for Flood Relief	Latin America and the Caribbean	Trinidad and Tobago	Multi-sector	10000000	04.08.2022	Riverine Floods
Building Community Resilience via Transformative Adaptation	Latin America and the Caribbean	Belize	Multi-sector	5000000	13.10.2023	Riverine Floods

Taking adaptation to the ground: A small Grants Facility for enabling local-level responses to climate change	Africa	South Africa	Multi-sector	2442682	10.10.2014	Riverine Floods
Integrated Programme To Build Resilience To Climate Change & Adaptive Capacity Of Vulnerable Communities in Kenya	Africa	Kenya	Multi-sector	9998302	10.10.2014	Riverine Floods, Landslides
Enhancing Resilience of Samoa's Coastal Communities to Climate Change	Asia-Pacific	Samoa	Multi-sector	8732351	14.12.2011	Riverine Floods, Landslides

Appendix B: Global Analysis (Non-Annex I Countries)

Analysis of Fatalities Caused by Climate-Related Hazards

Table 26: *Total number of fatalities from riverine floods, landslides and GLOFs in Asia-Pacific between 1950 and 2023, by sub-region.*

	Total Number of Fatalities		
Sub-Region	**Riverine Floods**	**Landslides**	**GLOFs**
West Asia	992	216	0
Central Asia	186	507	238
South Asia	53,489	7,134	8,753
East Asia	27,280	5,566	217
South-East Asia	11,776	5,972	0
Oceania	64	613	0

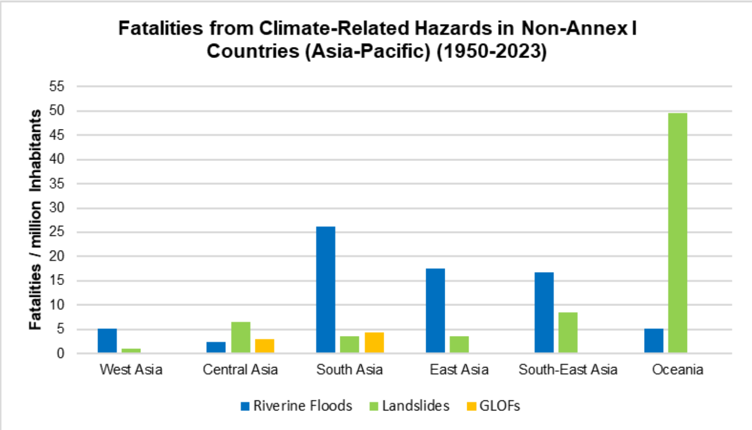

Figure 40: *Number of fatalities per million inhabitants from climate-related hazards in non-Annex I countries in Asia-Pacific between 1950 and 2023, by sub-region.*

Analysis of Project Funding Provided by the GCF and the AF

Analysis According to Individual Hazard Types

Table 27: *Total amount of GCF and AF adaptation funding provided to projects addressing riverine floods, landslides, GLOFs and snow avalanches in non-Annex I countries.*

	Amount of Funding [million USD]		
Hazard	**GCF**	**AF**	**GCF and AF**
Riverine Floods	967.33	146.92	1114.25
Landslides	500.01	88.96	589.91
GLOFs	36.96	10.41	47.37
Snow Avalanches	45.63	0	45.63

Regional Analysis According to Hazard Types and Hazard Combinations

Table 28: *Total amount of adaptation funding provided by the GCF for projects addressing individual hazard types and hazard combinations in non-Annex I countries, by region.*

	Hazard Type / Combination	**Amount of Funding [million USD]**				**Percentage of the Total Amount of Funding Provided for Each Region [%]**			
		Africa	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**	**Africa**	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**
Single Hazard Type	Riverine Floods	279.59	115.32	97.02	14.40	66.68%	26.06%	69.30%	34.74%
	Landslides	39.06	0	0	0	9.32%	0.00%	0.00%	0.00%
	GLOFs	0	36.96	0	0	0.00%	8.35%	0.00%	0.00%
	Snow Avalanches	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Hazard Type Combination	Riverine Floods, Landslides	100.66	271.74	42.97	0	24.01%	61.40%	30.70%	0.00%

	Riverine Floods, Landslides, Snow Avalanches	0	18.58	0	27.05	0.00%	4.20%	0.00%	65.26%
		419.31	**442.60**	**139.99**	**41.45**	100.00%	100.00%	100.00%	100.00%

Table 29: *Total amount of adaptation funding provided by the AF for projects addressing individual hazard types and hazard combinations, by region.*

	Hazard Type / Combination	**Amount of Funding [million USD]**				**Percentage of the Total Amount of Funding Provided for Each Region [%]**			
		Africa	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**	**Africa**	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**
Hazard Type	Riverine Floods	21.90	14.49	29.00	0	47.72%	36.08%	42.17%	0.00%
	Landslides	0	0	7.43	0	0.00%	0.00%	10.81%	0.00%
	GLOFs	0	10.41	0	0	0.00%	25.91%	0.00%	0.00%
	Snow Avalanches	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Hazard Type Combination	Riverine Floods, Landslides	24.00	15.26	32.35	9.93	52.28%	38.01%	47.03%	100.00%
	Riverine Floods, Landslides, Snow Avalanches	0	0	0	0	0.00%	0.00%	0.00%	0.00%
		45.90	**40.16**	**68.78**	**9.93**	100.00%	100.00%	100.00%	100.00%

Table 30: *Total amount of adaptation funding provided by both the GCF and the AF for projects addressing individual hazard types and hazard combinations, by region.*

	Hazard Type / Combination	**Amount of Funding [million USD]**				**Percentage of the Total Amount of Funding Provided for Each Region [%]**			
		Africa	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**	**Africa**	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**
Hazard Type	Riverine Floods	301.49	129.81	126.01	14.40	64.81%	26.89%	60.36%	28.03%
	Landslides	39.06	0	7.43	0	8.40%	0.00%	3.56%	0.00%
	GLOFs	0	47.37	0	0	0.00%	9.81%	0.00%	0.00%
	Snow Avalanches	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Hazard Type Combination	Riverine Floods, Landslides	124.65	287.00	75.32	9.93	26.80%	59.45%	36.08%	19.32%
	Riverine Floods, Landslides, Snow Avalanches	0	18.58	0	27.05	0.00%	3.85%	0.00%	52.65%
		465.20	**482.76**	**208.76**	**51.38**	100.00%	100.00%	100.00%	100.00%

Regional Analysis According to Individual Hazard Types

Table 31: *Total amount of GCF and AF adaptation funding provided to projects addressing riverine floods, landslides, GLOFs and snow avalanches in non-Annex I countries, by region.*

Hazard Type	**Amount of GCF and AF Funding [million USD]**			
	Africa	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**
Riverine Floods	426.14	435.39	201.34	51.38
Landslides	163.71	305.58	82.75	36.98
GLOFs	0	47.37	0	0
Snow Avalanches	0	18.58	0	27.05
	589.85	**806.91**	**284.10**	**115.42**

Table 32: *Total amount of GCF adaptation funding provided to projects addressing riverine floods, landslides, GLOFs and snow avalanches in non-Annex I countries, by region.*

Hazard Type	**Amount of GCF Funding [million USD]**			
	Africa	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**
Riverine Floods	380.25	405.63	134.00	41.45
Landslides	139.71	290.32	42.98	27.05
GLOFs	0	36.96	0	0

Snow Avalanches	0	18.58	0	27.05
	519.96	**751.49**	**176.98**	**95.55**

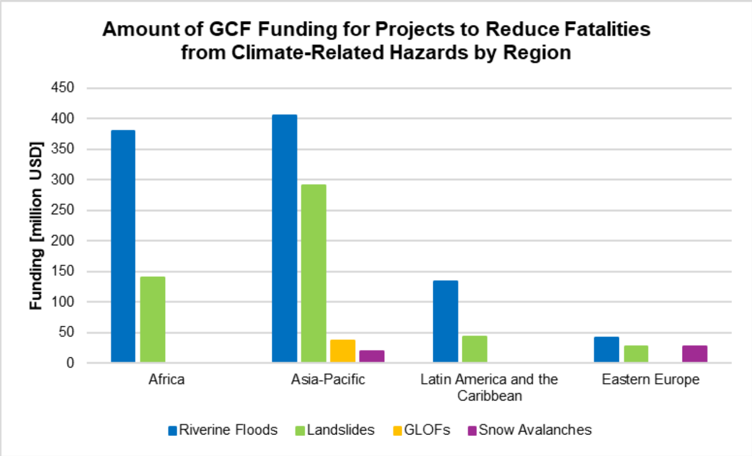

Figure 41: *Total amount of GCF adaptation funding for projects addressing individual hazard types in non-Annex I countries, by region.*

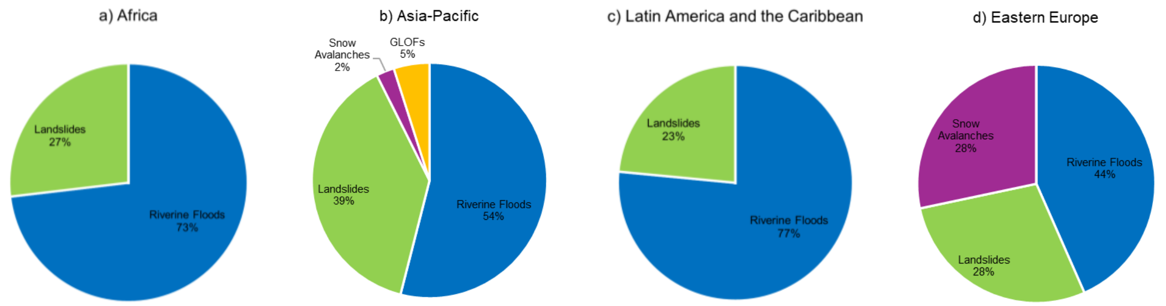

Figure 42: *Distribution of GCF adaptation funding for non-Annex I countries by hazard type and region, expressed as a percentage.*

Table 33: *Total amount of AF adaptation funding provided to projects addressing riverine floods, landslides, GLOFs and snow avalanches in non-Annex I countries, by region.*

Hazard Type	**Amount of AF Funding [million USD]**			
	Africa	**Asia-Pacific**	**Latin America and the Caribbean**	**Eastern Europe**
Riverine Floods	45.89	29.75	61.35	9.93
Landslides	24.00	15.26	39.78	9.93
GLOFs	0	10.41	0	0
Snow Avalanches	0	0	0	0
	69.89	**55.42**	**101.12**	**19.86**

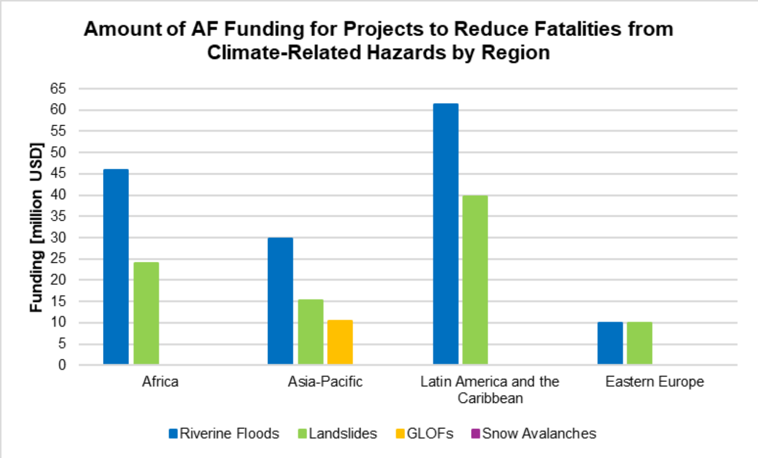

Figure 43: *Total amount of AF adaptation funding for projects addressing individual hazard types in non-Annex I countries, by region.*

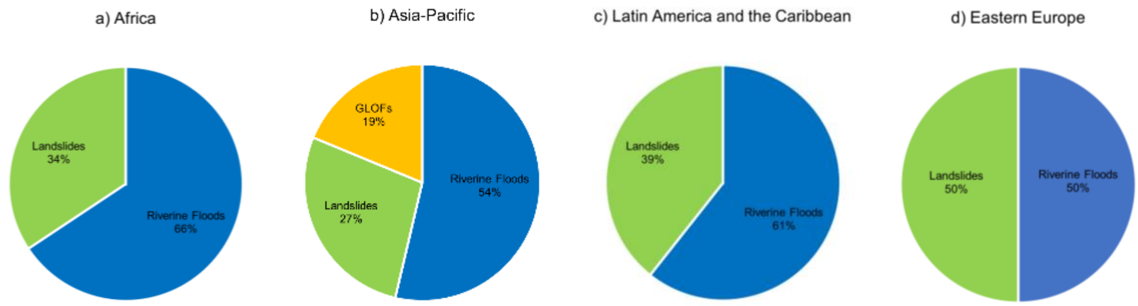

Figure 44: *Distribution of AF adaptation funding for non-Annex I countries by hazard type and region, expressed as a percentage.*

Appendix C: High Mountain Asia Analysis

Analysis of Project Funding Provided by the GCF and the AF

Local Analysis According to Individual Hazard Types

Table 34: *Total amount of GCF and AF adaptation funding provided to projects addressing riverine floods, landslides, GLOFs and snow avalanches in HMA, by country.*

	Amount of GCF and AF Funding [million USD]			
	Riverine Floods	**Landslides**	**GLOFs**	**Snow Avalanches**
Afghanistan	0	0	0	0
Bangladesh	19.68	0	0	0
Bhutan	0	0	0	0
China	0	0	0	0
India	0	0	0	0
Kazakhstan	0	0	6.50	0
Kyrgyzstan	8.58	8.58	6.50	8.58
Nepal	27.40	27.40	0	0
Pakistan	186.00	186.00	40.87	0
Tajikistan	5.00	5.00	6.50	0
Uzbekistan	10.00	10.00	6.50	10.00
	256.66	**236.98**	**66.87**	**18.58**

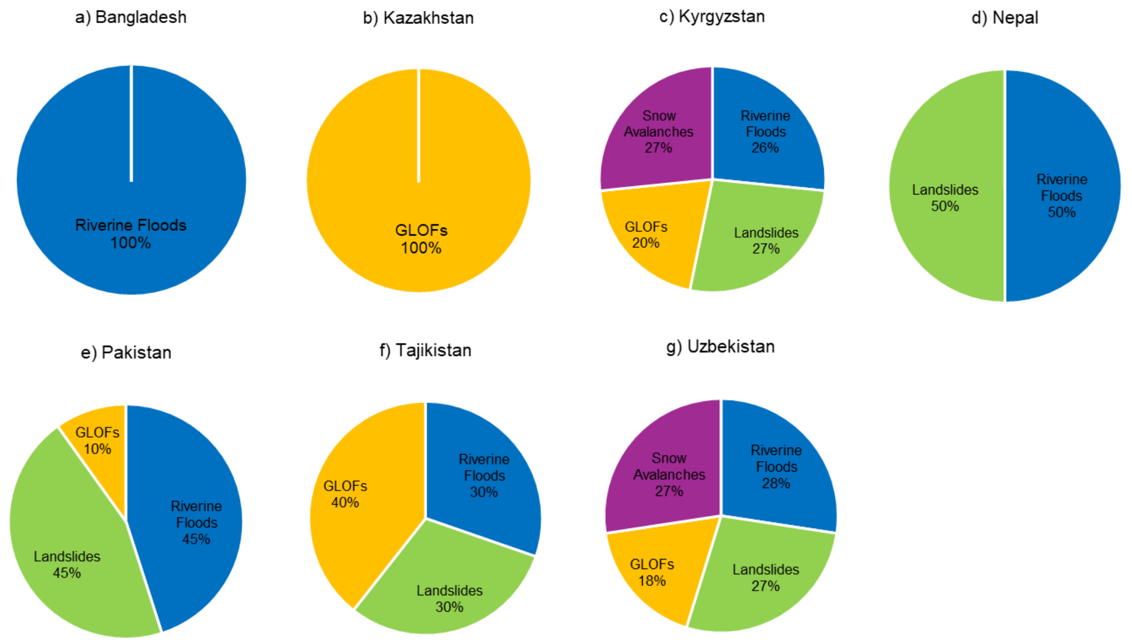

Figure 45: *Distribution of combined GCF and AF adaptation funding for countries in HMA by hazard type and country, expressed as a percentage.*

Table 35: *Total amount of GCF adaptation funding provided to projects addressing riverine floods, landslides, GLOFs and snow avalanches in HMA, by country.*

	Amount of GCF Funding [million USD]			
	Riverine Floods	**Landslides**	**GLOFs**	**Snow Avalanches**
Afghanistan	0	0	0	0
Bangladesh	9.68	0	0	0
Bhutan	0	0	0	0
China	0	0	0	0
India	0	0	0	0
Kazakhstan	0	0	0	0
Kyrgyzstan	8.58	8.58	0	8.58
Nepal	27.40	27.40	0	0
Pakistan	186.00	186.00	36.96	0
Tajikistan	5.00	5.00	0	0
Uzbekistan	10.00	10.00	0	10.00
	246.66	**236.98**	**36.96**	**18.58**

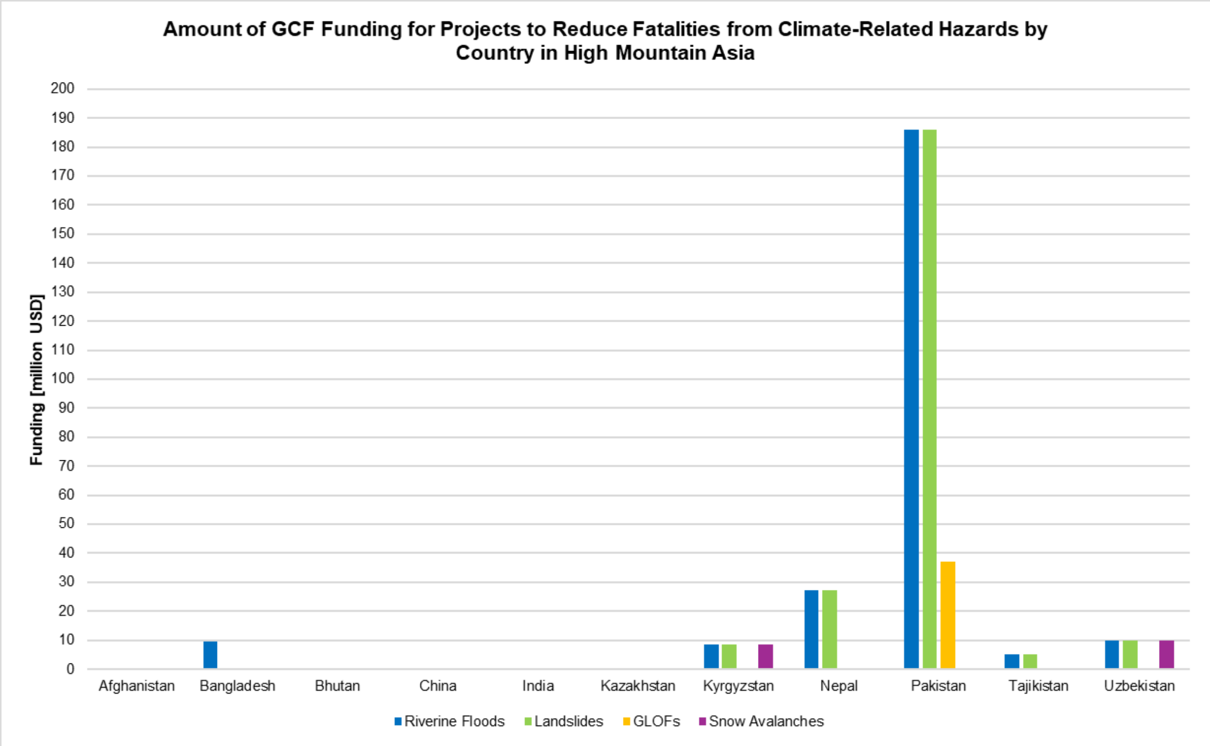

Figure 46: *Total amount of GCF adaptation funding for projects addressing individual hazard types in HMA, by country.*

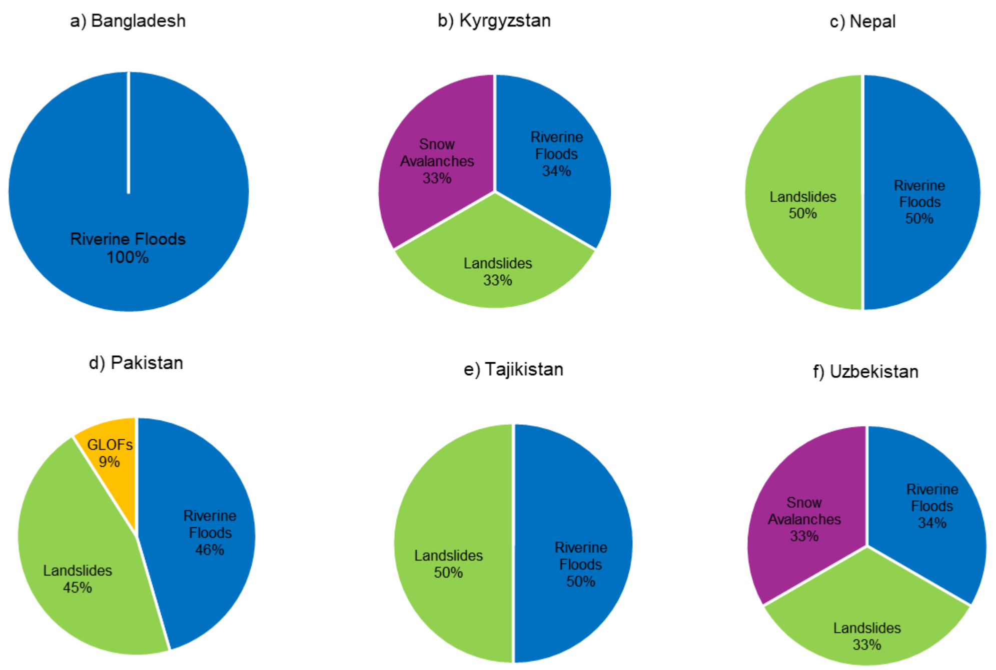

Figure 47: *Distribution of GCF adaptation funding for countries in HMA by hazard type and country, expressed as a percentage.*

Table 36: *Total amount of AF adaptation funding provided to projects addressing riverine floods, landslides, GLOFs and snow avalanches in HMA, by country.*

	Amount of AF Funding [million USD]			
	Riverine Floods	**Landslides**	**GLOFs**	**Snow Avalanches**
Afghanistan	0	0	0	0
Bangladesh	10.00	0	0	0
Bhutan	0	0	0	0
China	0	0	0	0
India	0	0	0	0
Kazakhstan	0	0	6.5	0

Kyrgyzstan	0	0	6.5	0
Nepal	0	0	0	0
Pakistan	0	0	3.91	0
Tajikistan	0	0	6.5	0
Uzbekistan	0	0	6.5	0
	10.00	**0**	**29.91**	**0**

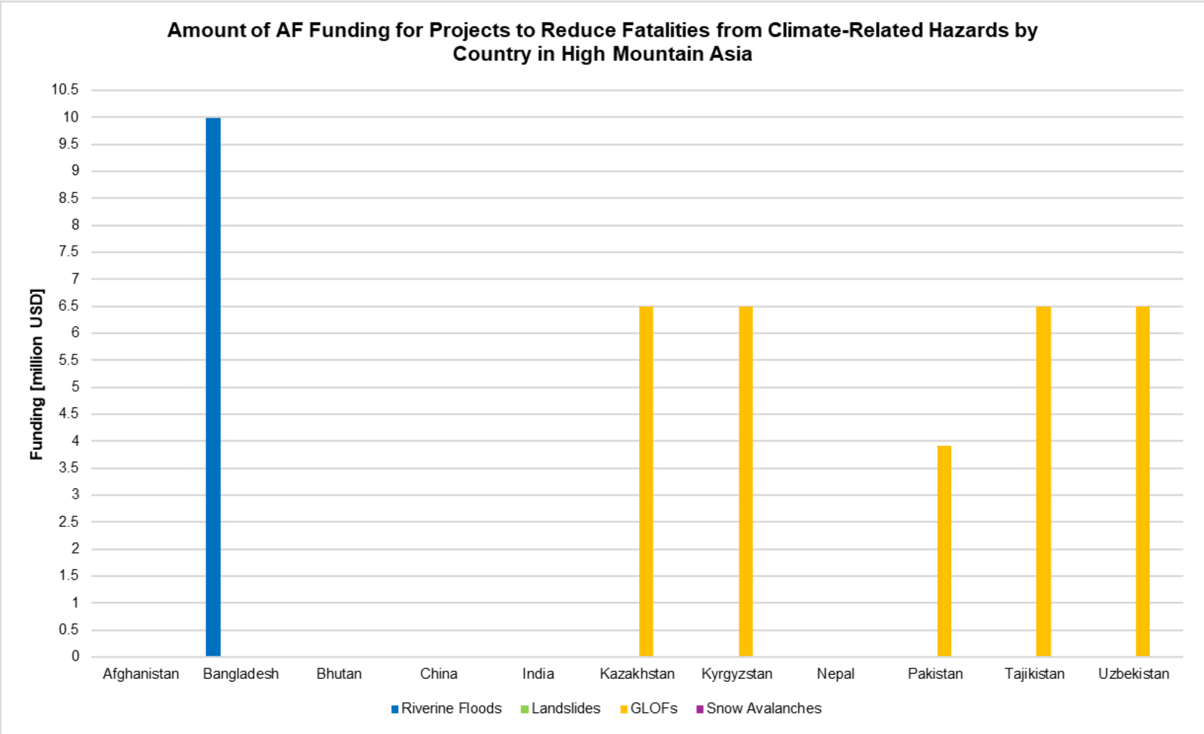

Figure 48: *Total amount of AF adaptation funding for projects addressing individual hazard types in HMA, by country.*

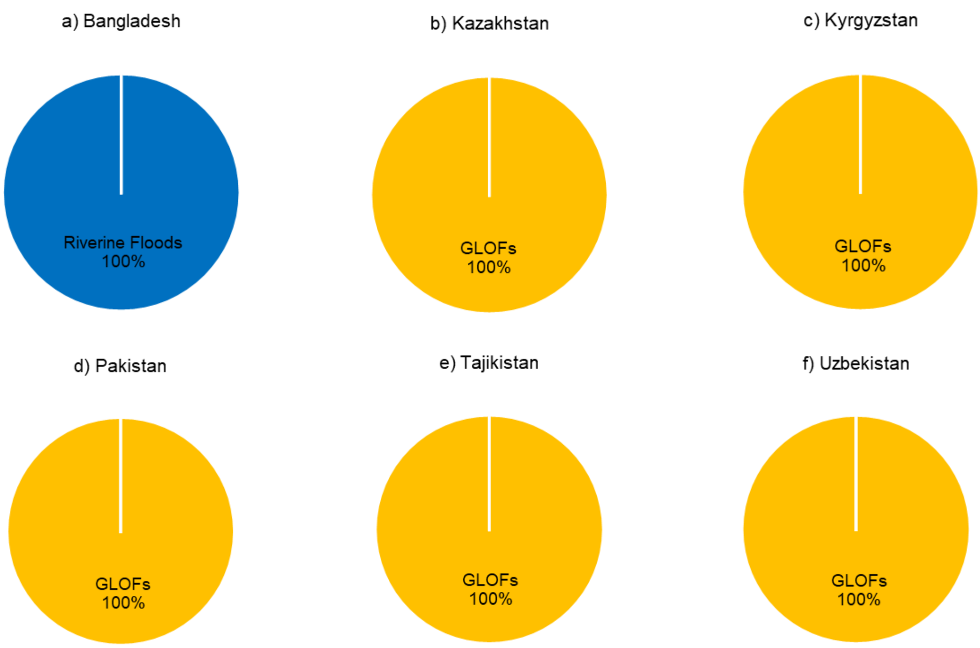

Figure 49: *Distribution of AF adaptation funding for countries in HMA by hazard type and country, expressed as a percentage.*

Comparison of Number of Fatalities and Funding Amounts

Regional Analysis

Table 37: *Data used for the correlation analysis for countries in HMA regarding the relationship between fatalities per million inhabitants and the amount of adaptation funding for projects addressing climate-related hazards, focusing on GCF funding.*

	Riverine Floods		**Landslides**		**GLOFs**		**Snow Avalanches**	
Country	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**
Afghanistan	59.31	0	11.14	0	0.35	0	20.39	0
Bangladesh	42.34	9.68	0.61	0	0	0	0	0
Bhutan	245.89	0	0	0	24.59	0	0	0
China	16.85	0	3.53	0	0.15	0	0.02	0
India	20.77	0	2	0	4.16	0	0.63	0
Kazakhstan	0.65	0	0	0	1.01	0	0.81	0
Kyrgyzstan	0.43	8.58	37.90	8.58	14.90	0	0.87	8.58
Nepal	58.94	27.40	54.48	27.40	1.72	0	19.72	0
Pakistan	26.62	186	0.93	186	0.03	36.96	1.50	0
Tajikistan	16.49	5	23.67	5	2.43	0	11.35	0
Uzbekistan	0	10	0.03	10	0	0	0	10

Table 38: *Data used for the correlation analysis for countries in HMA regarding the relationship between fatalities per million inhabitants and the amount of adaptation funding for projects addressing climate-related hazards, focusing on AF funding.*

	Riverine Floods		**Landslides**		**GLOFs**		**Snow Avalanches**	
Country	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**
Afghanistan	59.31	0	11.14	0	0.35	0	20.39	0
Bangladesh	42.34	9.68	0.61	0	0	0	0	0
Bhutan	245.89	0	0	0	24.59	0	0	0
China	16.85	0	3.53	0	0.15	0	0.02	0
India	20.77	0	2	0	4.16	0	0.63	0
Kazakhstan	0.65	0	0	0	1.01	6.5	0.81	0
Kyrgyzstan	0.43	0	37.90	0	14.90	6.5	0.87	0
Nepal	58.94	0	54.48	0	1.72	0	19.72	0
Pakistan	26.62	0	0.93	0	0.03	3.91	1.50	0
Tajikistan	16.49	0	23.67	0	2.43	6.5	11.35	0

Table 39: *Data used for the correlation analysis for countries in HMA regarding the relationship between fatalities per million inhabitants and the amount of adaptation funding for projects addressing climate-related hazards, focusing on the combined funding amounts of the GCF and AF.*

	Riverine Floods		**Landslides**		**GLOFs**		**Snow Avalanches**	
Country	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**	**Fatalities / million inhabitants**	**Funding [million USD]**
Afghanistan	59.31	0	11.14	0	0.35	0	20.39	0
Bangladesh	42.34	19.68	0.61	0	0	0	0	0
Bhutan	245.89	0	0	0	24.59	0	0	0
China	16.85	0	3.53	0	0.15	0	0.02	0
India	20.77	0	2	0	4.16	0	0.63	0
Kazakhstan	0.65	0	0	0	1.01	6.5	0.81	0
Kyrgyzstan	0.43	8.58	37.90	8.58	14.90	6.5	0.87	8.58
Nepal	58.94	27.40	54.48	27.40	1.72	0	19.72	0
Pakistan	26.62	186	0.93	186	0.03	40.87	1.50	0
Tajikistan	16.49	5	23.67	5	2.43	6.5	11.35	0
Uzbekistan	0	10	0.03	10	0	6.5	0	10

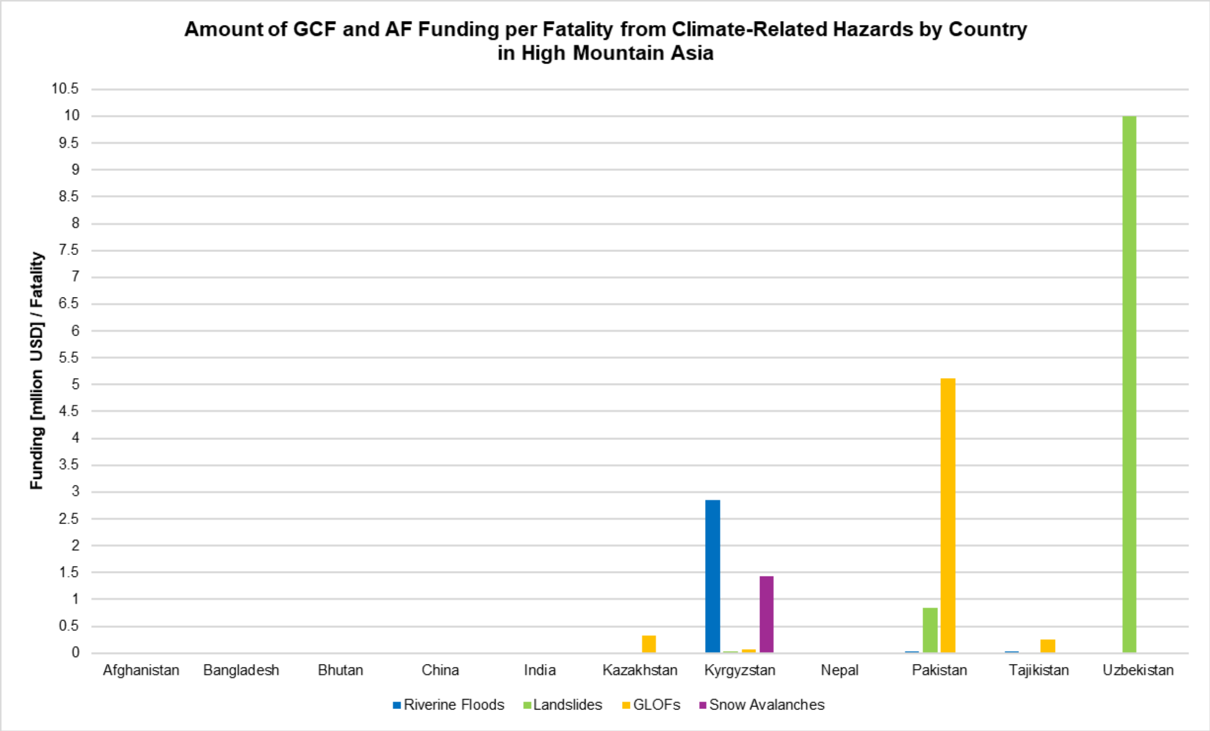

Figure 50: *Amount of adaptation funding per fatality provided by the GCF and the AF for projects addressing climate-related hazards in HMA, by country.*

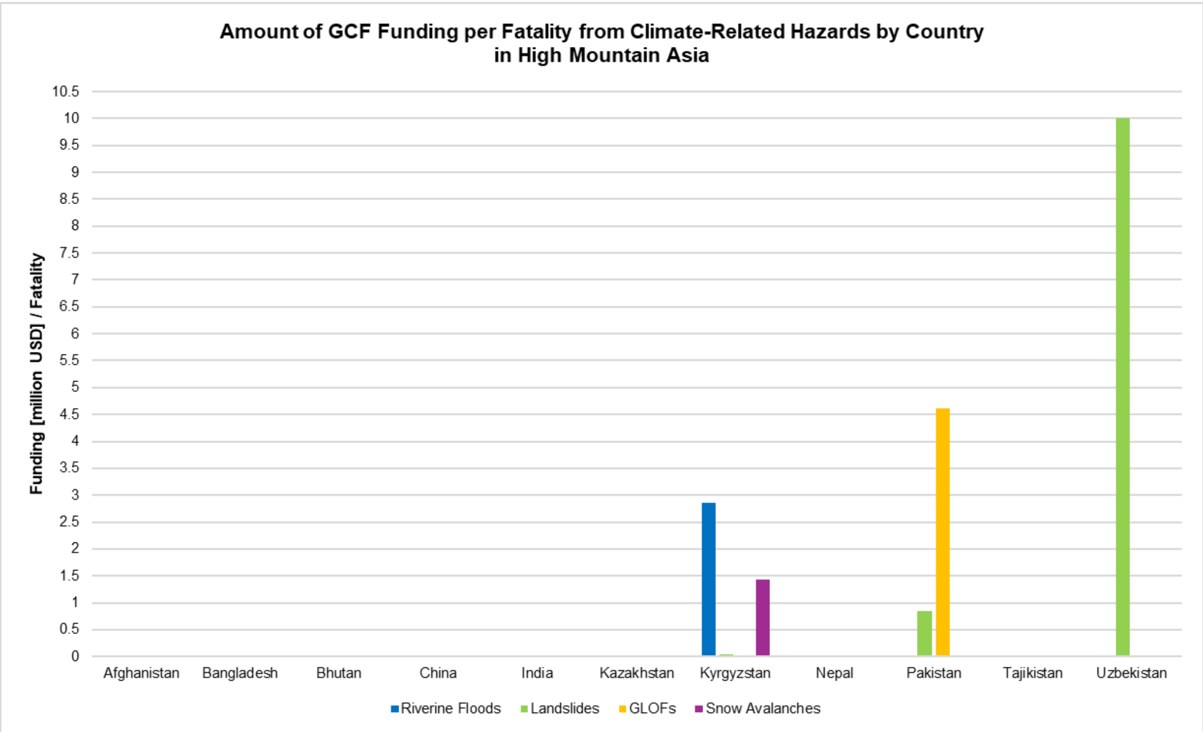

Figure 51: *Amount of adaptation funding per fatality provided by the GCF for projects addressing climate-related hazards in HMA, by country.*

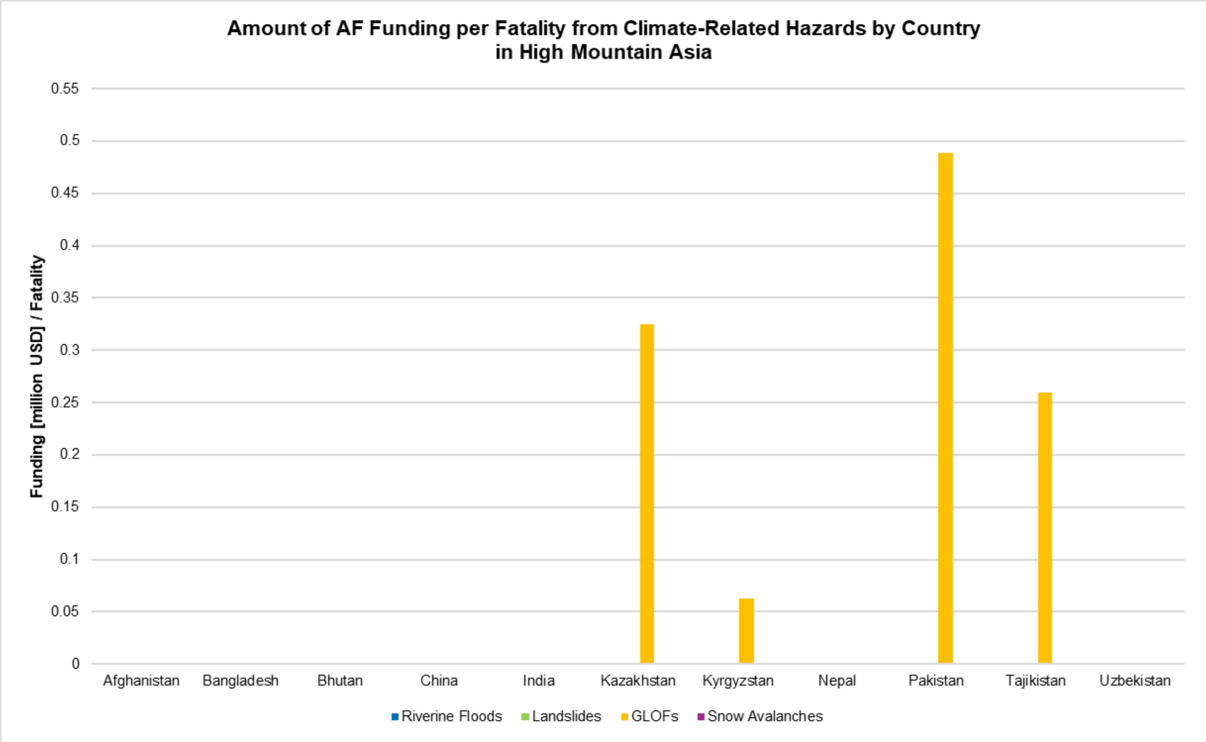

Figure 52: *Amount of adaptation funding per fatality provided by the AF for projects addressing climate-related hazards in HMA, by country.*

Appendix D: Funding Allocation Criteria of the Green Climate Fund and the Adaptation Fund

Table 40: *GCF assessment criteria for program/project proposals (taken from GCF, 2023b).*

Criterion	Definition	Coverage area
Impact potential	Potential of the program/project to contribute to the achievement of the Fund's objectives and result areas	• Mitigation impact • Adaptation impact
Paradigm shift potential	Degree to which the proposed activity can catalyse impact beyond a one-off project or program investment	• Potential for scaling-up and replication and its overall contribution to global low-carbon development pathways consistent with a temperature increase of less than 2°C • Potential for knowledge and learning • Contribution to the creation of an enabling environment • Contribution to the regulatory framework and policies • Overall contribution to the climate-resilient development pathways consistent with a country's climate change adaptation strategies and plans
Sustainable development potential	Wider benefits and priorities	• Environmental co-benefits • Social co-benefits • Economic co-benefits • Gender-sensitive development impact
Needs of the recipient	Vulnerability and financing needs of the beneficiary country and population	• Vulnerability of the country • Vulnerability groups and gender aspects • Economic and social development level of the country and the affected population • Absence of alternative sources of financing • Need for strengthening institutions and implementing capacity
Country ownership	Beneficiary country ownership of and capacity to implement a funded project or program (policies, climate strategies and institutions)	• Existence of a national climate strategy • Coherence with existing policies • Capacity of implementing entities, intermediaries or executing entities to deliver • Engagement with civil society organizations and other relevant stakeholders
Efficiency and effectiveness	Economic and, if appropriate, financial soundness of the program/project	• Cost-effectiveness and efficiency regarding financial and non-financial aspects • Amount of co-financing • Program/project financial viability and other financial indicators • Industry best practices

Strategic Priorities, Policies, And Guidelines of the Adaptation Fund (SPPG)

When it comes to the evaluation of project and program proposals, the AF Board must lay particular focus on (see AF, 2022b, pp. 3–4):

- Consistency with national sustainable development strategies and adaptation planning processes, including, where appropriate, national adaptation plans (NAPs), nationally determined contributions (NDCs), adaptation communications, national development plans, poverty reduction strategies, national communications and national adaptation programs of action (NAPAs) and other voluntary adaptation reports and relevant instruments, where they exist;
- Economic, social and environmental benefits from the projects and adaptation impact;
- Meeting national technical standards, where applicable;
- Cost-effectiveness of projects and programs;
- Arrangements for management, including for financial and risk management;
- Arrangements for monitoring and evaluation and impact assessment;
- Avoiding duplication with other funding sources for adaptation for the same project activity;
- Moving towards a programmatic approach, where appropriate;
- Advancing gender equality and the empowerment of women and girls.

In determining how to allocate the funds made available by the AF to eligible Parties, the following considerations need to be taken into account (see AF, 2022b, p. 4):

- Level of vulnerability;
- Level of urgency and risks arising from delay;
- Ensuring access to the fund in a balanced and equitable manner;
- Lessons learned in project and program design and implementation to be captured;
- Securing regional co-benefits to the extent possible, where applicable;
- Maximizing multi-sectoral or cross-sectoral benefits;
- Adaptive capacity to the adverse effects of climate change.

Personal Declaration

I hereby declare that the submitted thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the thesis.

T. Bearth

Thalwil, 30th September 2024

Tanja Bearth