Chapter 1
Introduction

The Hindu Kush-Himalayas (HKH) are the youngest mountains on earth and are still tectonically active. They are undergoing uplift and, therefore, the region is characterised by steep slopes and a high rate of surface erosion. In addition to the geological conditions, intense seasonal precipitation in the central and eastern Himalayas, particularly during the summer monsoon, and in the western Himalayas and the Hindu Kush during winter, triggers various types of natural hazards. Floods are one of the most common forms of natural disaster in this region. Intense monsoon rainfall or cloudbursts can cause devastating flash floods in the middle mountains (500–3500 masl). Rapid melting of snow accumulated during winter is the main cause of flash floods in the Hindu Kush and western Himalayas. Furthermore, the region is experiencing widespread deglaciation, most probably as a result of global climate change (WWF 2005; Mool et al., 2001; Xu et al. 2007). Deglaciation has caused the birth and rapid growth of many glacial lakes in the region. These lakes are retained by unstable natural moraine dams that tend to break due to internal instabilities or external triggers leading to a glacial lake outburst flood (GLOF) that can cause immense flooding downstream. Landslides due to intense rainfall in combination with geological instabilities can cause ephemeral damming of rivers. Another type of flash flood common in the region results from the outbreak of dammed lakes. These dammed lakes can break resulting in flash flood.

1.1 Features of Flash Floods

The topography and geology of the Himalayas are the prime factors leading to flash floods. Abrupt slope gradients and poor and fragile watersheds in the hills produce very high flow velocities.

Economic and social factors are also responsible for flash floods. Haphazard encroachment on natural resources due to population growth results in the degradation of watersheds (e.g., ICIMOD 2006; Mehta 2007b; Dixit 2003). The resilience of watersheds is low and regeneration is slow compared to consumption, which leads to various effects on environmental and ecological conditions.

Some characteristics of flash floods and the differences between flash floods and riverine floods are shown in Table 1.

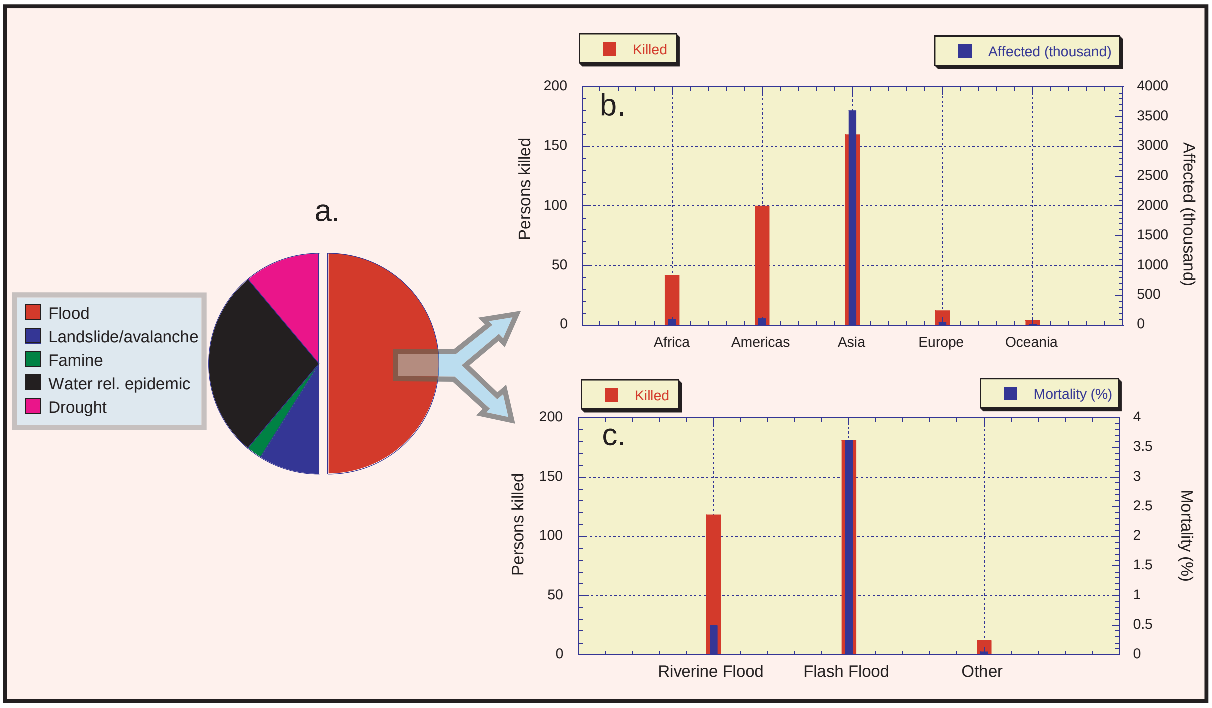
Flash floods in the HKH region

Hundreds of lives and billions of dollars worth of property and investment in high-cost infrastructure are lost in the HKH region every year due to landslides, debris flows, and floods, along with the destruction of scarce agricultural lands. In the last decade of the 20th Century, floods killed about 100,000 persons and affected 1.4 billion people worldwide. The number of events, as well as the number of deaths, is increasing (Jonkman 2005; ICIMOD 2007). Floods account for almost half of all water-induced disasters worldwide, and the number of people killed and affected per event is significantly higher in Asia than elsewhere (Figure 1). This number is even higher for flash flood events than for riverine floods (Jonkman 2005). The region’s flash floods occur predominantly in the mountainous parts of south Asia, such as the greater Himalayan range, the Hindu Kush, the Karakorum, the Tien Shan, the Kun Lun, and the Pamir, where they are a major hazard.

Table 1: Flash floods and riverine floods

	Flash floods	Riverine floods
Features	– rapid water level rise above natural channels – reaches peak flow within minutes up to a few hours – rapid recession (within minutes to few hours) – often dissipate quickly – not necessarily related to base flow levels – short lag times	– slow water level rise beyond natural channels – reaches peak flow within days to weeks – slow recession (within days to weeks) – mostly coinciding with high base flow levels – medium to long lag times
Causes	– very high intensity rainstorms/cloudbursts – rapid snow/glacial melt due to rapid increase in temperature – dam (both artificial and natural) breaks	– prolonged seasonal precipitation of low to high intensity – seasonal snow and glacial melt
Associated problems	– often carry high sediment and debris loads – very high hydraulic force and erosive power	– inundation
Frequency	– occasionally, any time during the year	– annually during rainy season
Affected areas	– river plains and valleys – alluvial fans – mostly local extent – generally small to medium areas are affected	– river plains and valleys – local to regional extent – large areas can be affected
Predictability	– very difficult to forecast	– with appropriate technology and measures in place, forecasting is easily possible
Potential mitigation measures	– early warning systems – community preparedness and awareness – appropriate emergency measures	– real-time flood forecasting – community preparedness and awareness – appropriate emergency measures

Source: Xu et al. 2006



Sources: Based on data drawn from Jonkman 2005; ICIMOD 2007

Figure 1: People killed and affected by floods: a. types of water-related disasters; b. number of people killed and affected by floods disaggregated by continent; and c. number of people killed disaggregated by type of flood

1.2 Causes of Flash Floods

Flash floods have various causes. The most common are intense rainfall, landslide dam outbursts, and glacial lake outbursts – described in more detail below. They can also be caused by the failure of artificial dams and levees, poor management of hydraulic structures, rapid melting of snow and ice, quick release of stored glacial water, and others.

Intense rainfall

Intense rainfall is a very common cause of flash floods. These events may last from one day to several days. The main meteorological phenomena that cause intense rainfall in the region are cloudbursts, a stationary monsoon trough, and monsoon depressions. Figure 2 illustrates the mechanism of cloudbursts.

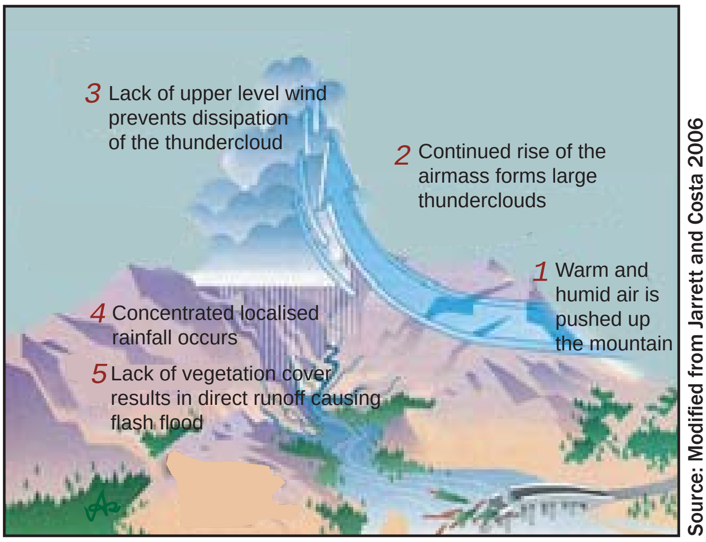


Figure 2: The mechanism of a cloudburst

Landslide dam outburst

Intense rainfall on a localised bare slope causes direct runoff and soil erosion. This erosion intensifies as it comes down the slope, causing a landslide or land slip. Debris from the latter can create a natural dam across a stream or river. When the water level rises above the dam or the weight of water upstream of the dam exceeds its holding capacity, the dam will burst, causing a flash flood. Figure 3 shows a schematic representation of the formation of a natural dam.

These kinds of dams often form in steep and narrow valleys where there is less room to spread the landslide mass. Formation of the dam is a very complex phenomenon starting from slumping or sliding of a soil mass. Besides heavy rainfall, soil erosion can be triggered by earthquakes and volcanic eruptions.

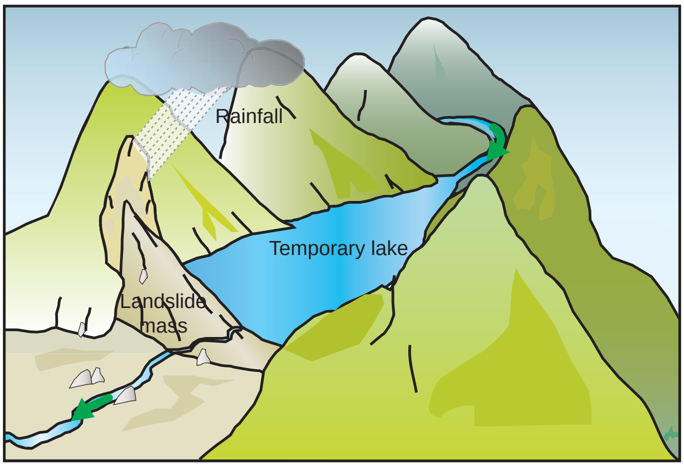


Figure 3: Formation of a natural dam

Glacial lake outburst

Glacial lakes are directly related to glacier fluctuation processes, which in turn are attributed to climate variability. The Himalayan glaciers have been in general retreat since the end of the Little Ice Age around the middle of the 19th Century. However, the retreat has accelerated in recent decades, most probably due to anthropogenic climate change, which is highly pronounced in the HKH region. The retreat of a glacier leaves behind a large void, which is filled by meltwater, thus forming a moraine-dammed glacial lake. These natural dams are composed of unconsolidated moraines consisting of boulders, gravel, sand, and silt; they are structurally weak and unstable, and undergo constant changes due to slope failure, slumping, and so on. They are susceptible to catastrophic failure, causing glacial lake outburst floods. Glacial lakes may burst due to tectonic movement, seepage through the moraines, or overtopping of the moraines.

Flash flood in Chitral, Pakistan, 4 May 2007

At 5pm on Friday 4 May 2007, there was panic in Chitral when everybody in five villages ran to save their lives and those of their dear ones.

Within just half an hour, 42 well-established families were homeless and looking for food, clothes, and shelter. The wealth accumulated by these families and the community from generation to generation – houses, fertile agricultural land, beautiful gardens full of fruit-bearing trees, green fields with standing crops, animal sheds full of livestock, irrigation channels, roads, water supply lines, electric poles and supply lines, transport – everything except their lives was gone. Thunderstorms had started at 4pm and continued for an hour followed by a half-hour hailstorm, causing flash flooding more intense than ever before experienced in the history of Chitral. Life in Chitral was completely paralysed. When the flood receded, the green agricultural lands were full of boulders and standing crops were completely ruined. It seemed as though there had been no human settlement before. The flood moved at such a tremendous speed that it moved huge boulders, tore out trees, destroyed buildings, and obliterated bridges. The damage was estimated at over 30 million Pakistani Rupees (US $0.5 million).

Flash flood in Central Nepal, on 19-20 July 1993

In July 1993, the Kulekhani catchment in central Nepal experienced intense rain, which caused several devastating flash floods that transported high loads of debris and sediment into the reservoir of Nepal's only storage-type hydropower station, thereby reducing its life by several decades. Other installations of the power plant were severely damaged. The highway joining the capital city to the rest of the country was seriously damaged, with several bridges and kilometres of paving washed away. Fourteen hundred lives were lost. The total impact was so enormous that it pushed the country back in its development efforts by several years.

(Dhital et al. 1993)

1.3 Impacts of Flash Floods

Flash floods contain water flowing at high velocity with large amounts of debris (Figures 4 and 5). They can be highly destructive and can sweep away critical infrastructure and lifelines of mountain communities. The heavy debris loads increase the destruction, and often damming can occur at constricted areas such as gorges. The major impacts can be separated into socioeconomic and environmental.

S.H. Shah

Figure 4: Debris fan due to a flash flood in July 2006 in Brep, Chitral, Pakistan

S. Dhungana

Figure 5: Large boulders deposited by a flash flood in Madi River, Central Nepal in August 2003

Socioeconomic

Landslides and debris flows associated with flash floods can have major socioeconomic impacts on people, their homes, and possessions, industrial establishments, and lifelines such as highways, railways, and communication systems.

The indirect impacts of flash floods include such things as reduced real estate values in areas threatened by landslides and loss of tax revenue on property devalued as a result of landslides. Like other natural disasters, flash floods can cause loss of industrial, agricultural, and forest productivity, and of tourist revenue as a result of damage to land or facilities or interruptions to transportation systems (Figure 6). Flash floods can also cause loss of domestic animal productivity because of death, injury, or psychological trauma. The disruption of transportation systems causes financial hardship as people cannot transport their perishable agricultural products to market.

Environmental

Flash floods in the Himalayan region have enormous impacts on the natural environment. The mudflows cover terraced land with boulders and debris, damage standing crops, and render fields useless for agriculture until massive efforts are made to reclaim them (Figure 4). In the foothills and plains of the river valleys, floods often deposit coarse sediment, which damages valuable crops and renders the land infertile.

Riverbanks in such areas are subjected to severe bank erosion and loss of soil, which in turn provides more sediment for the river to deposit downstream. Switching from an old course to a new one is common after a severe flash flood. Landslides often give rise to debris flows that aggrade river beds and cause flow diversion and riverine flood. This in turn aggravates the flood susceptibility of the downstream floodplains by creating drainage congestion.


S. Khan

Figure 6: Damage to highway by a flash flood in July 2005 in Garam Chasma, Chitral, Pakistan