Chapter 2
General Characteristics of HKH Related to Flash Floods

This chapter provides a brief review of the natural features of the region relevant to flash floods.

2.1 Climate[3]

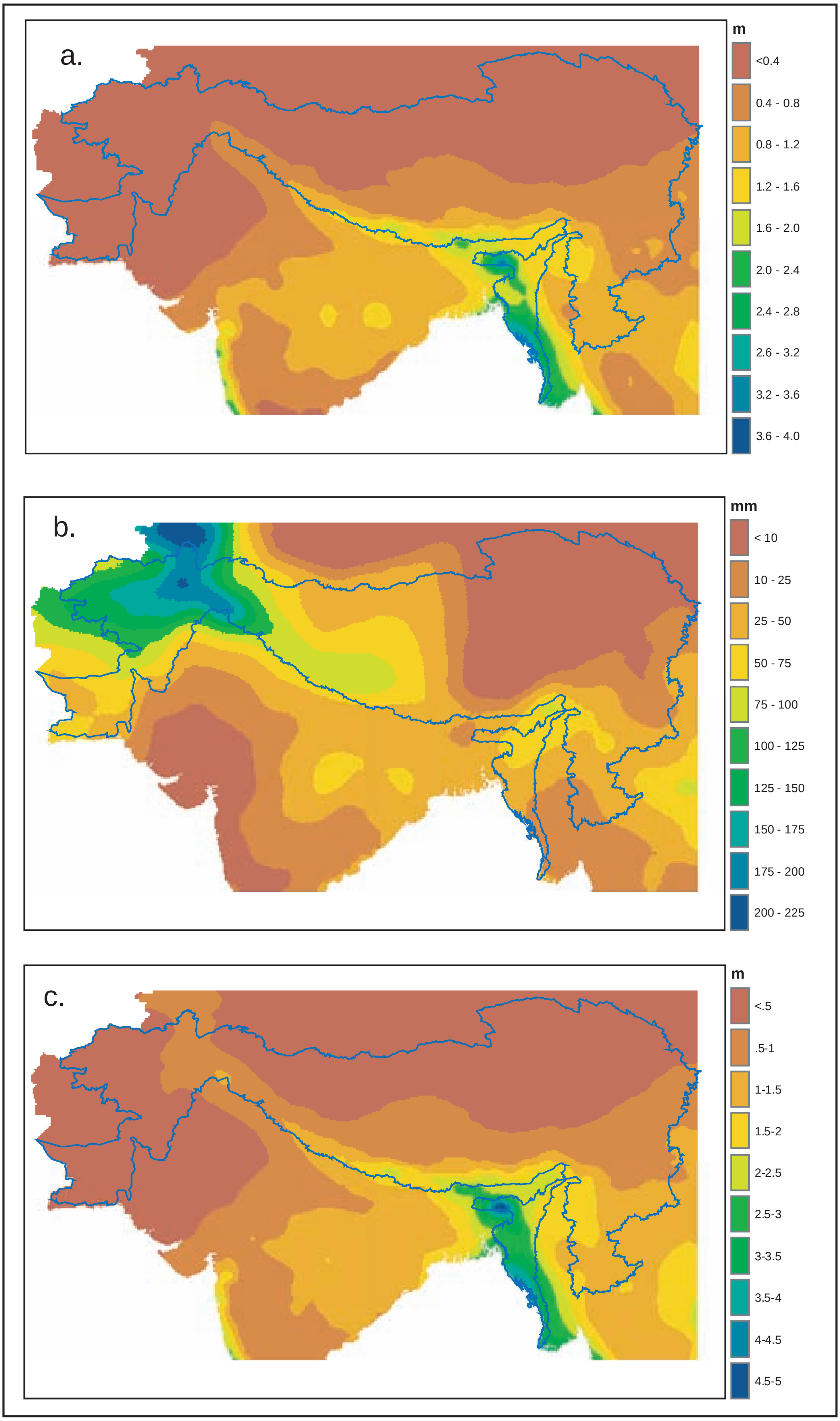
Due to its massive and high mountain systems, the HKH region acts as a barrier to atmospheric circulation, both the summer monsoon and the winter westerlies. The region's climate, although dominated by the monsoon system, can be characterised by a number of meso- and micro-climates due to topographic variations. The climate in the Himalayas, as in the other parts of South Asia, is dominated by the monsoon system. The summer monsoon originates in the Bay of Bengal and, therefore, the amount of monsoon precipitation decreases from east to west (Figure 2a). The summer monsoon is much longer in the eastern Himalayas (e.g., Assam), where it lasts for five months (June-October); it lasts for four months (June-September) in the central Himalayas (Sikkim, Nepal, and Kumaon), and two months (July-August) in the western Himalayas (e.g., Kashmir) (Chalise and Khanal 2001). The summer monsoon loses its dominance over annual precipitation in the western Himalayas (Figure 3a), where the winter westerlies deliver a significant amount of precipitation (Figure 3b). Winter precipitation is greater in the western parts of the region and less in the eastern parts. The summer monsoon has a meridional pattern as well: precipitation is higher on the windward side of the Himalayas due to the orographic effect on the monsoon air masses, while the leeward side receives less rain. Consequently the Trans-Himalayan zone and the Tibetan plateau receive very little summer precipitation. In the Tibetan Plateau summer monsoon precipitation occurs between May and September (Mei'e et al. 1985). Annual precipitation decreases from southeast to northwest: from about 800 mm at Markam and Songpan in western Sichuan to 400-500 mm at Lhasa, 200-300 mm at Tingri, and less than 100 mm at Ngari Prefecture (Mei'e et al. 1985). Depending on the location, the annual precipitation variation can be quite high (Figure 4). However, in general, the summer monsoon is the predominant source of precipitation in the region (Figures 3, 4).

Temperatures in the Himalayas vary inversely with elevation at a rate of about 0.6°C per 100m, and due to the rugged terrain, wide ranges of temperatures are found over short distances. Local temperatures also correspond to season, aspect, and slope (Zurick et al. 2006). Owing to the thin atmosphere above the Tibetan Plateau and ample and intense radiation, the surface temperature has a large diurnal variation, although its annual temperature range is relatively small. The temperature range in the northern mountainous region of Pakistan and Afghanistan is greater and the annual range of temperature is also quite large. In Chitral (1450 masl), for example, temperatures can reach as high as 42°C and as low as -14.8°C (Shamshad 1988).

High-intensity rainfall is a characteristic microclimatic feature of the region (Domroes 1979). Such high-intensity rainfalls have important implications for flash floods known as intense rainfall floods (IRFs). In July of 1993, 540 mm of rainfall was recorded in 24 hours in the central part of Nepal (Dhital et al. 1993). This caused a devastating flash flood with colossal damage to infrastructure and lives, and disrupted normal life for several months. These types of events are rather common in the HKH.

The western Himalayas and the Hindu Kush can receive large amounts of snow during the winter, caused by westerly disturbances from the Mediterranean. The snow not only affects peoples' livelihoods with avalanches and blocked transport routes, but, in case of rapid warming in spring, can also lead to flash floods caused by rapid snowmelt.

[3] With contributions from Mr. R. Rajbhandari, Tri Chandra Campus, Tribhuvan University.



Source: CRU data; New et al. 2002

Figure 2: Precipitation distribution in the HKH region: a. during the summer monsoon; b. winter; and c. annual. The blue outline shows the approximate boundary of the region

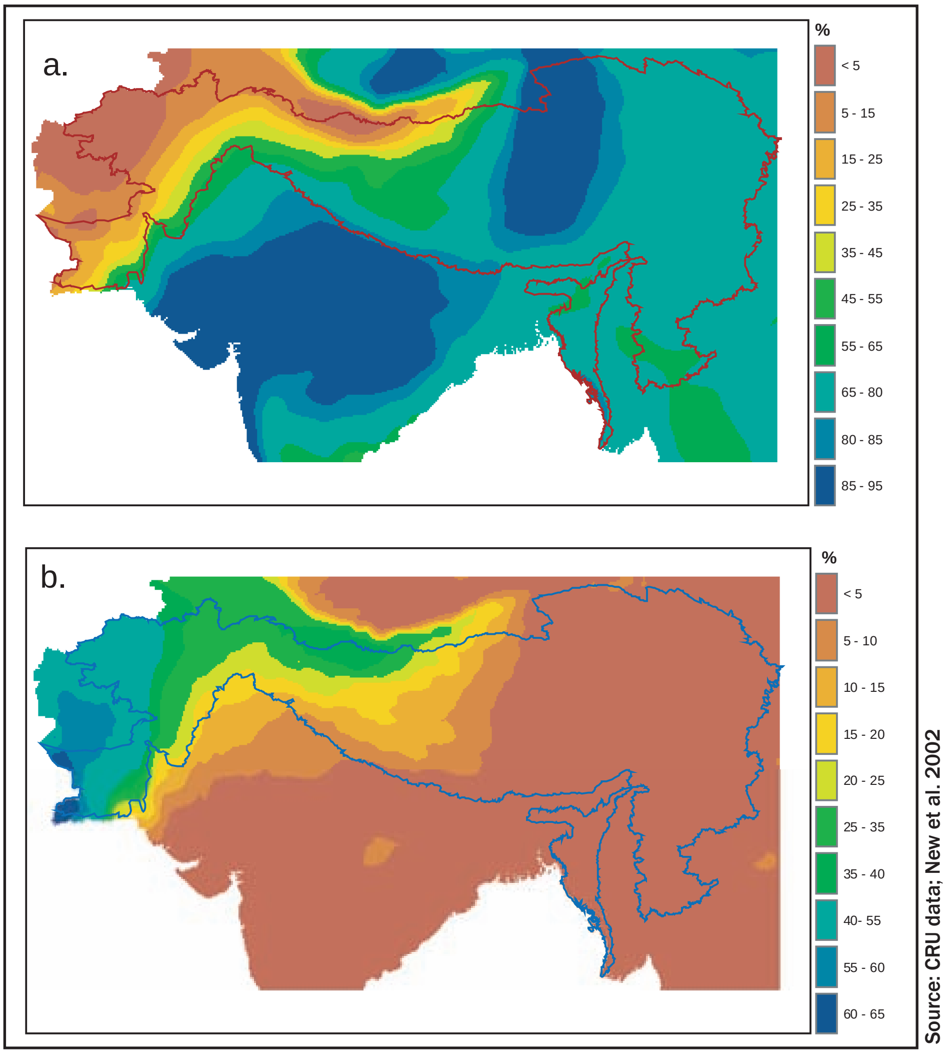


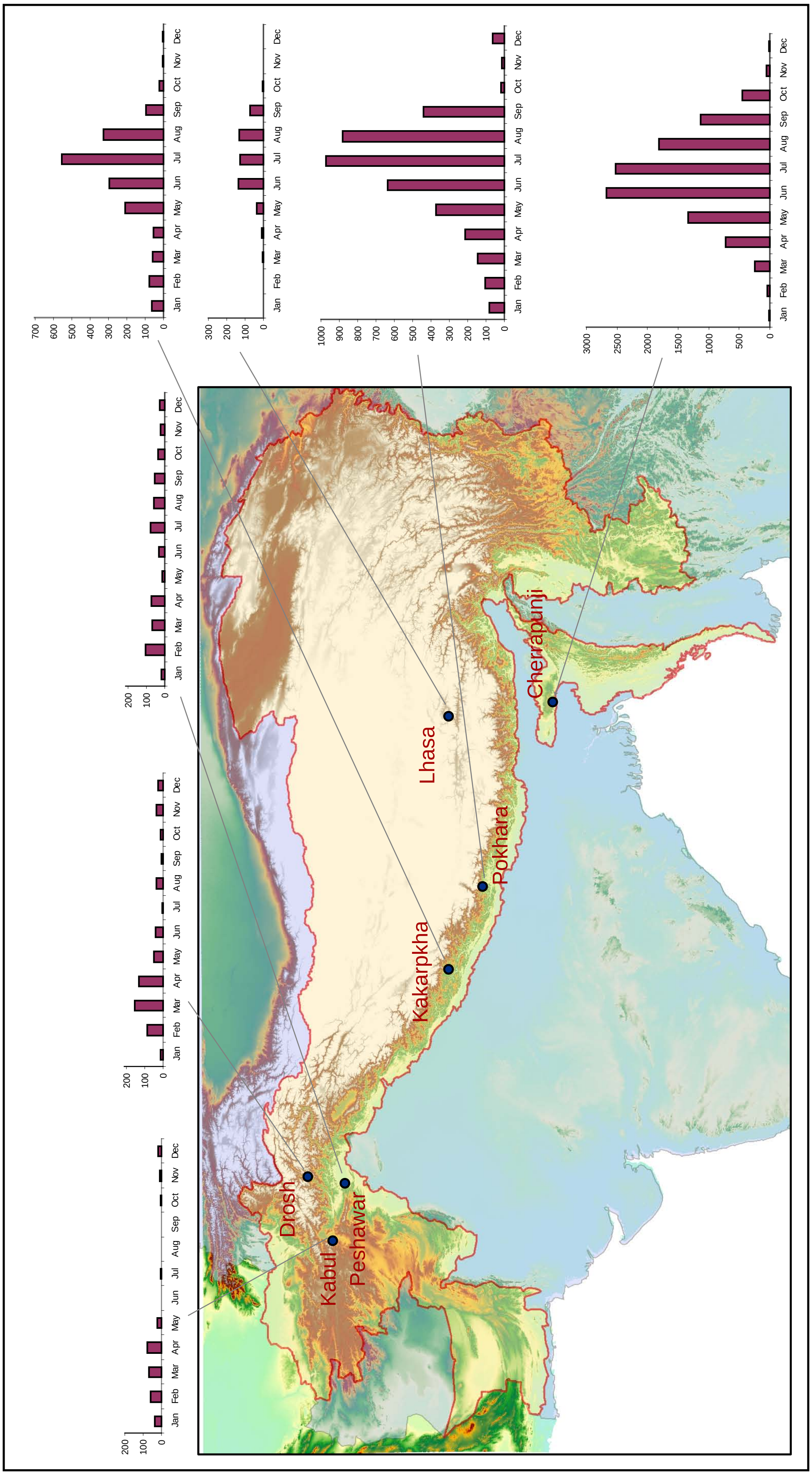
Figure 3: Fraction of annual precipitation contributed by: a. summer monsoon and b. winter precipitation. The outline shows the approximate boundary of the region

2.2 Hydrology

The Himalayan range is an important source of runoff, which is significantly higher in the summer than in the winter (Figure 5). The runoff generated in these areas sustains the flow of eight[4] major rivers that originate from the HKH region (Figure 6). Despite different locations of the river basins, their flow hydrographs generally peak during spring or summer, which supports the importance of summer precipitation in runoff generation (Figure 7).

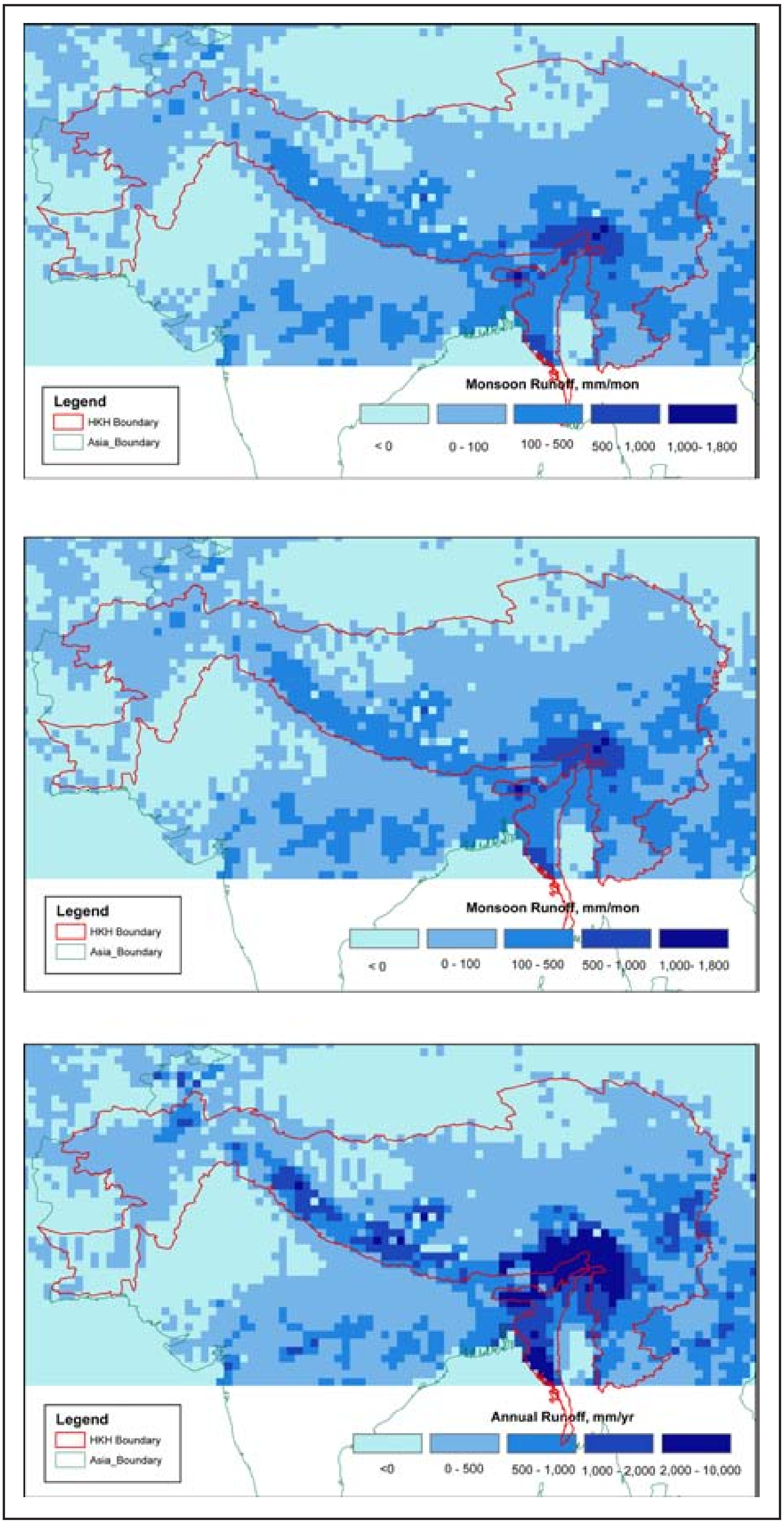
Many Himalayan rivers originate from glaciers, which are in general retreat, probably as a result of climate change (Fujita et al. 2001; Ageta and Kadota 1992; Kadota et al. 1997; Kulkarni et al. 2005; Shing and Bengtsson 2004, 2005; Archer 2001; Shiyan et al. 1996). Retreating glaciers often leave behind voids that are filled by meltwater and are called glacial lakes. Glacial lakes can burst due to internal instabilities in the natural moraine dam retaining the lake (for example, collapse due to hydrostatic pressure, erosion, overtopping, internal structural failure) or due to external triggers such as rock/ice avalanche, earthquake, and so on. These catastrophic processes are known as glacial lake outburst floods (GLOFs). A GLOF can result in flow of water and debris several orders of magnitude greater than seasonal high flow. Bhutan, China, Nepal, and Pakistan have suffered a number of GLOFs in the past.

[4] There are now considered to be ten major river basins: eight with their main basin area within the HKH and two with only some of their area within the HKH.



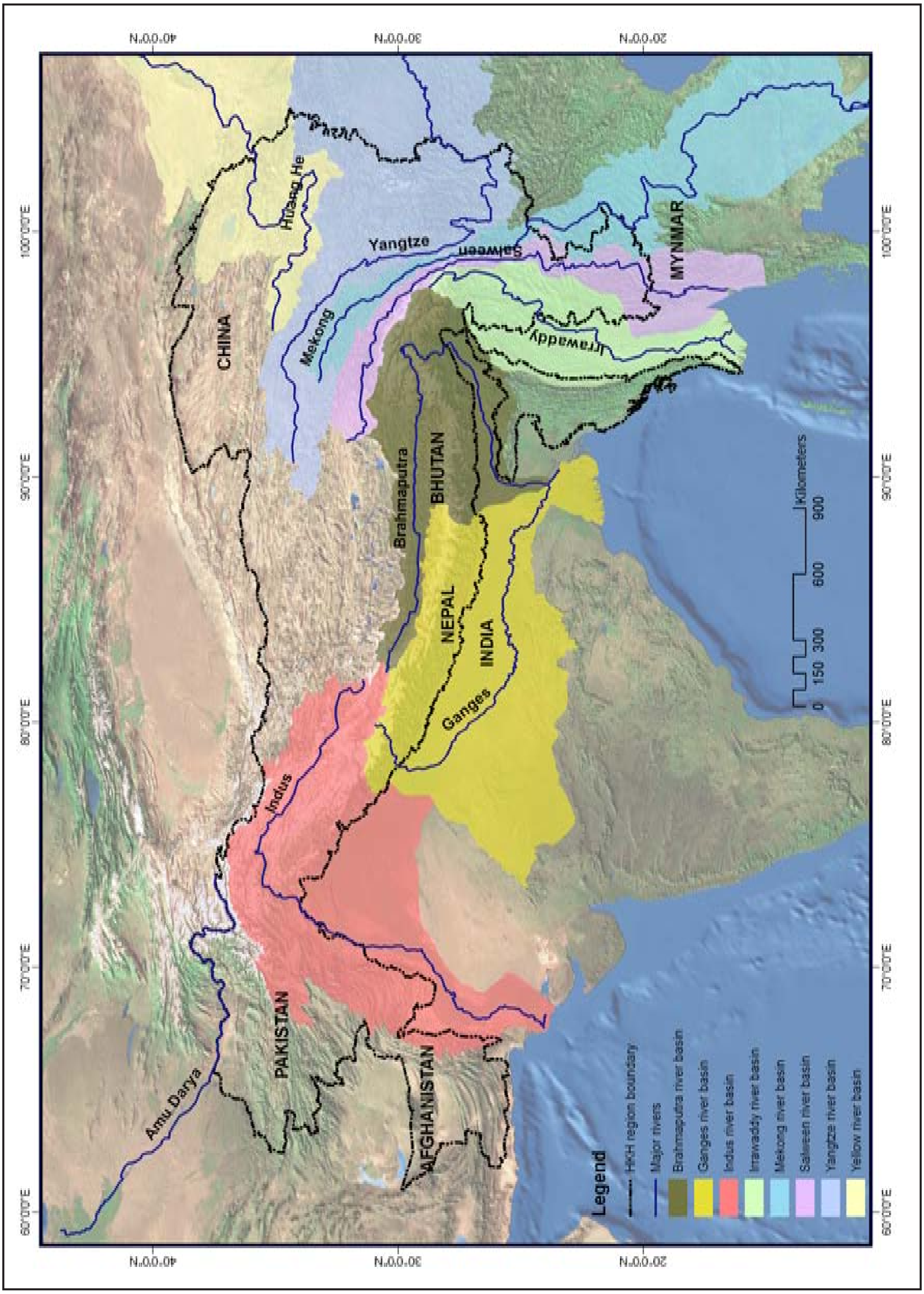
Data source: ICIMOD; background: ESRI

Figure 4: Seasonal variations in precipitation at different locations in the HKH region. The red outline shows the approximate boundary of the region



Source: http://www.grdc.sr.unh.edu/ (Accessed May 2007)

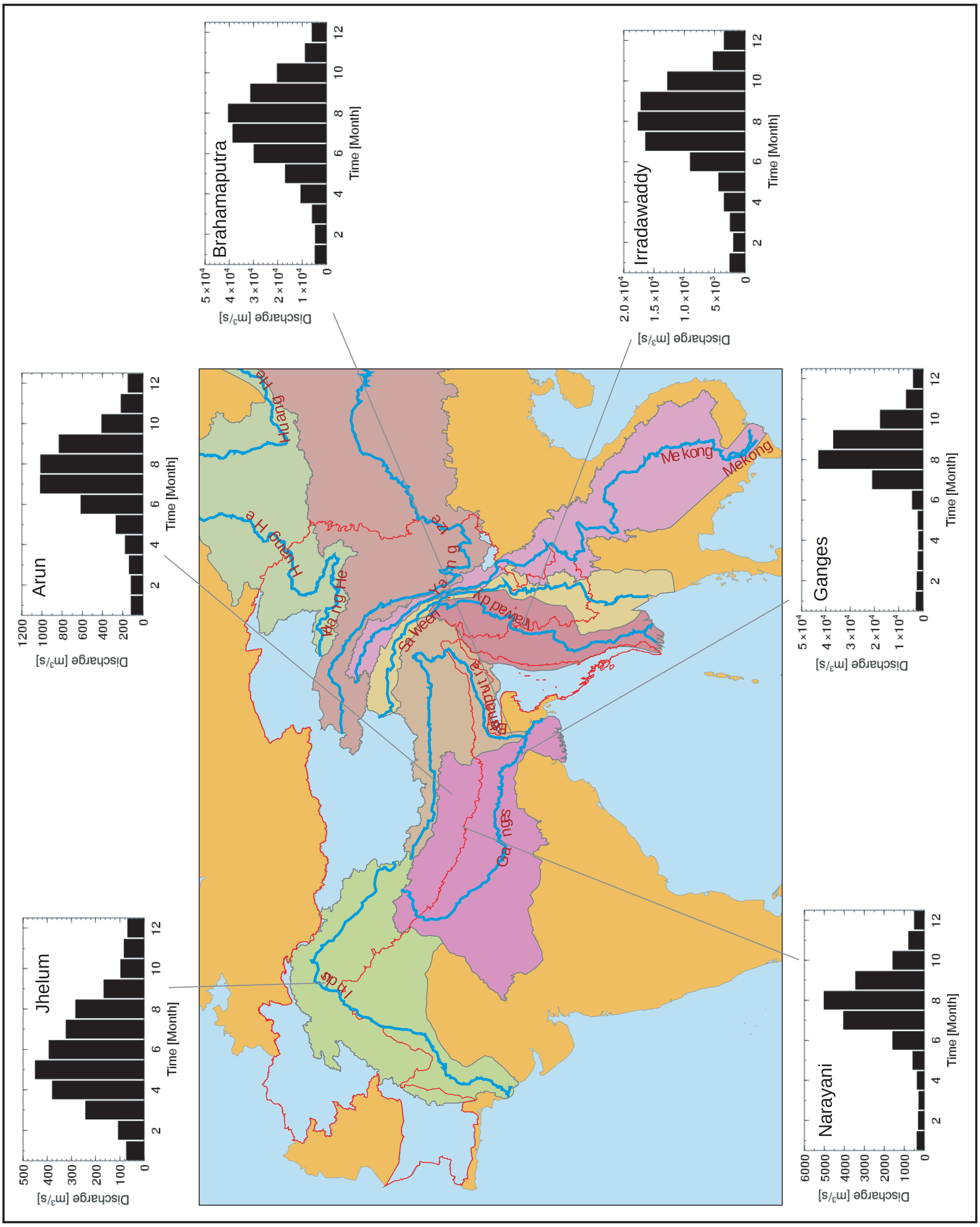
Figure 5: Runoff generated from the HKH region



Source: ICIMOD; background ESRI

Figure 6: Map of the HKH region and the eight[5] major river basins

[5] There are now considered to be ten major river basins: eight with their main basin area within the HKH and two with only some of their area within the HKH.



Source: ICIMOD archive

Figure 7: Seasonal variations in the flow of select rivers in the HKH region

2.3 Geology

Due to the steep and unstable slopes of the Himalayas, the region is prone to recurrent and often devastating landslides. Such landslides and debris flows, released by torrential rain or seismic activity, may cause temporary dams across river courses and result in the impoundment of immense volumes of water. Subsequent overtopping, or water breaking through the earth dam, will result in a landslide dam outburst flood (LDOF) event similar to a GLOF. Although these phenomena are well known to local people, they are sudden and unpredictable and may cause a large number of deaths and much damage to property.

2.4 Other Factors

Failure of artificial structures can also cause tremendous flash floods. As more and more river basins are being exploited by people, flash floods due to failure of human-made hydraulic structures will likely increase. Occasionally, the uncoordinated operation of a hydraulic structure causes a flash flood resulting in loss of life and property.