Flash Flood Risk Assessment for Afghanistan

Mohammad Tamim Bahadurzai, Arun B. Shrestha

Why Flash Flood Risk Assessment?

Flash floods are floods that rise and fall rapidly with little or no advance warning (www.weather.com). They are usually caused by intense rainfall, or a sudden outburst of a landslide dam or glacial lake, the rapid melting of snow, or by failure of artificial hydraulic structures. In this chapter, we concentrate on the first three causes.

Flash floods are common in mountainous regions. Afghanistan is prone to flash floods because of its steep slopes in headwaters (Figure 1). Flash floods occur mainly as a result of heavy rainfall combined with rapid snowmelt, mostly during the spring months. Besides water, flash floods carry considerable amounts of debris. Amu River, for example, has an elevation difference of 2700 m between Pamir and Kham Ab and carries about 250 million cubic metres of sediment from flash floods every year. The river erodes large areas of land in Afghanistan. In general, Hairatan district in the north, and Harirood and Farahrood rivers (Hilmand basin) in the western part, are flash flood-prone. Lack of vegetation and denudation of the mountain areas are the major causes of flash floods. In recent years, flash floods have been occurring more frequently and with increasing ferocity in countries like Afghanistan.

Flash floods can damage lives, infrastructure, and the environment, and affect the livelihoods of mountain people. Assessing its risk forms the core of flash flood disaster risk management. Risk assessment helps identify potential risk reduction measures. Integrated into the development planning process, it can identify actions that can meet both development needs and reduce risk.

Flash flood damages can be reduced by establishing a proper flood control management structure to manage floods and reduce their ill effects. Taking precautionary steps, measures, and actions with the help of the government will deliver communities, agricultural land, infrastructure, and livelihoods in flash flood-prone areas to safety.

What is Risk?

The term 'risk' covers a whole range of meanings. For this manual, we consider the Source-Pathways-Receptor-Consequence model of assessing risk (Figure 2) proposed by Goulby and Samuals (2005).

Figure 1: **Major river basins of Afghanistan. Source: AIMS/FAO**

Risk arises when there is a hazard which has a source or initiator (for example, a cloudburst); when there are pathways between the source and the receptors (for example, flood routes including defense structures, overland flow or landslide); and there are receptors – people, property, the environment along the path that will likely be on the receiving end and will be adversely affected.

The first two components of risk (source and pathways) relate to **hazard**, and the last two (receptor and consequences) to **vulnerability**. Vulnerability describes the great possibility of a receptor (for example, a house) to suffer damage from a flash flood.

Assessing Flash Flood Risk

Risk assessment is essential in making decisions about managing flash flood risks (Figure 3). The steps in risk assessment include:

1. Characterising the area
2. Assessing hazard or determining hazard level and intensity
3. Assessing vulnerability, and
4. Assessing risk

Figure 2: **Pathway-Receptor-Consequence Conceptual Model**

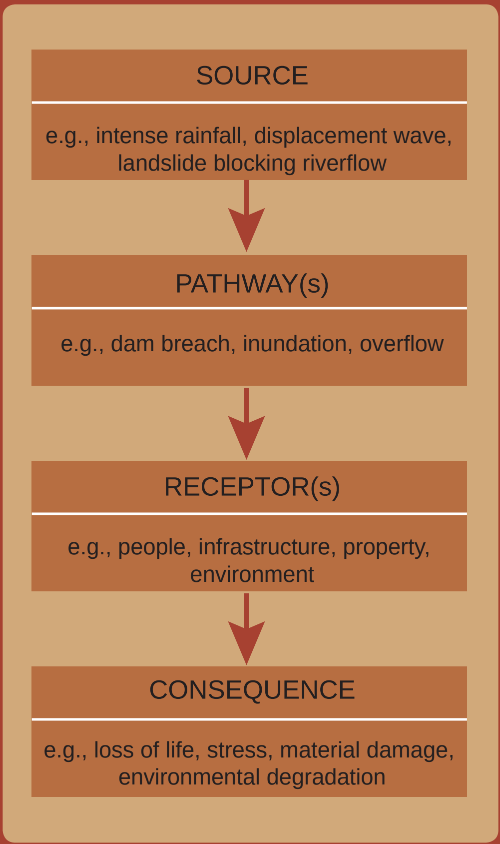
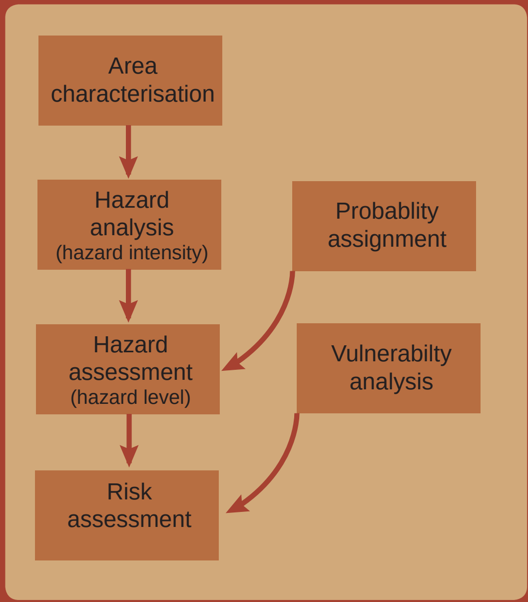


Figure 3: **Procedural diagram for flash flood risk analysis**



Source: modified from Colombo et al. 2002, and Goulby and Samuals 2005

This section provides guidelines for conducting flash flood risk assessment based on these steps. The assessment can be conducted by provincial level officers of the Ministry of Energy and Water (MEW) who have a good understanding of natural channel hydrology and hydraulics as well as some knowledge of spatial mapping.

Step 1: Characterising the area

Characterising an area prone to flash floods is important for both hazard and vulnerability assessment. The following information should be collected to give an idea of the character of the potentially affected area:

1. **Geography** (physical and social): for example, the length of a river section in an area, communes and provinces involved, peculiarities of the area, and its population
2. **Geology and geomorphology**: the properties of rocks and soil in the area, river courses, or pathways

Box 1: **Two approaches to managing flash floods**

Managing hazard exposure, and vulnerability is the best way to manage flash floods. Vulnerability can be both physical and social, thus requiring structural and non-structural measures. Building structures such as check dams and embankments can lessen the frequency or probability and intensity of flash floods and thus addresses physical vulnerability. Non-structural measures focus on community exposure and vulnerability. Changing or regulating land use, employing early warning systems, and developing community resilience in various ways are some examples of non-structural measures which can help communities cope in an event of a flash flood or some other disaster.

Box 2: **Risk assessment for risk management**

The results of risk assessment are generally presented in risk maps. What these maps show – potential areas at risk – can be communicated to community organisations working in potentially affected areas and can help communities anticipate, prepare for, and manage the risks. Aided by risk maps, communities can prepare in the following ways.

- By establishing local flash flood management committees and making flash flood contingency plans
- By managing flash floods using new technologies and local knowledge using participatory approaches (refer to the chapter on 'Working with Communities', and 'An Overview of Monitoring and Evaluation' for some participatory approaches and 'Local Knowledge on Disaster Preparedness' on documenting local knowledge), working with government agencies, communities, involving NSPs, CDCs, existing local committees including the Shuras, religious leaders, and elders
- Making disaster preparedness plans, conducting awareness raising activities within communities, and devising local early warning systems
- Based on the maps, identifying safe areas for shelter and restricting construction and other activities in flood-prone areas
- Constructing flash flood control structures such as embankments using gabion boxes and local materials
- Drawing the attention of national and international donor agencies for support in disaster preparedness and management
- Improving headwaters, watershed management, and better managing water resource structures
- Conducting training and workshops on flash flood preparedness

3. **Hydrology and hydraulics**: the properties of the river such as flow amount, cross-sections, slope, and other properties of the area's rivers and waterways
4. **Vegetation**: types of plants and trees that grow in the area
5. **Land use**: for example, land use types such as agricultural land, forest and other wooded land, built-up and related land, wet open land, dry open land with special vegetation cover, open land with or without insignificant vegetation cover
6. **Existing counter-measures**: for example, check dams, bioengineering work, others
7. **Historical analysis of floods that have taken place in the area**: for example, floods that have happened in the past (local memory, damaged environment, national and local databanks, newspapers, interviews from victims can be the sources of information)

Step 2: Assessing hazard or determining hazard level and intensity

Hazard analysis includes defining the strength of the flash flood (flash flood hazard intensity), and scenarios in the areas where it will hit (catchments). Determining hazard intensity is a step towards determining hazard levels. A simple way of assigning flash flood hazard intensity is shown in Table 1, although in reality, assigning hazard intensity is much more complicated. Alternatively, hazard intensity can be determined by the level of the anticipated flooding.

Assigning probability to a hazard scenario

To conduct a flash flood hazard assessment, assign probability levels to a hazard scenario. This means, determining how frequently a flash flood of a certain intensity is likely to occur in an area again. In the case of an intense rainfall flood, the return period or frequency of the rainfall occurring again can be used as the probability level. The return period or frequency of flooding caused by an intense rainfall can also be alternately used to determine probability (Table 2). Unfortunately, such information is not easily available in Afghanistan because of the lack of hydrometeorological observations. In such a case, the assessment would have to rely on secondary information such as books, reports from newspapers, and local accounts of community people.

Table 1: **A simple way of assigning hazard intensity**

Hazard intensity	Danger to population close to the stream	Danger to population in settlement (about 500m from the stream)	Danger to population 1 km away from the stream	Danger to population more than 1 km away from the stream
High	yes	yes	yes	yes
Moderate	yes	yes	yes	no
Moderately Low	yes	yes	no	no
Low	yes	no	no	no

Table 2: **Probability level of a hazard scenario**

Probability level	Frequency
High	at least once in 10 years
Moderate	once in 10 to 30 years
Moderately Low	once in 30 to 100 years
Low	less frequent than once in 100 years

It is difficult to assign probability levels to other types of flash floods such as landslide dam outburst floods (LDOFs) and glacial lake outburst floods (GLOFs) as they often occur only once or occasionally. In such cases, it is customary to use probability levels based on the characteristics of the lake, dam, or the surrounding environment (Table 3).

Table 3: **Pro bability levels for LDOFs and GLOFs**

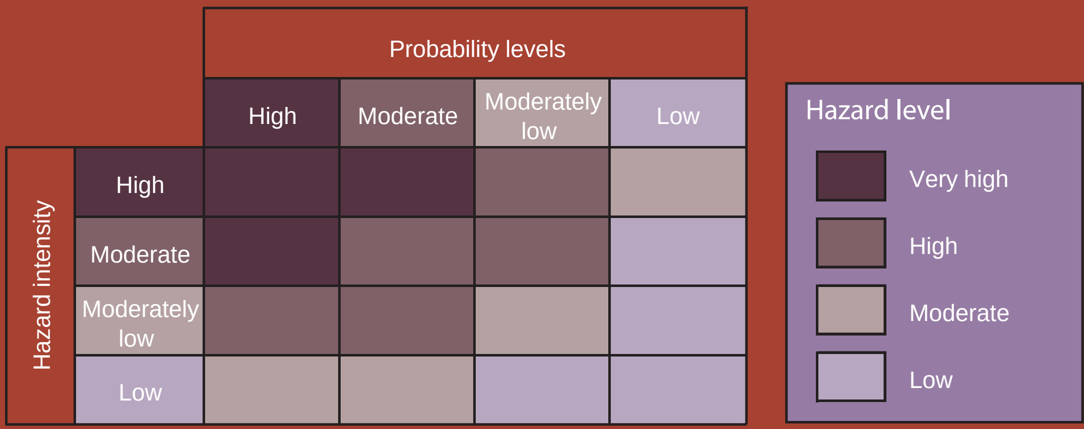
Indicator	Characteristic	Qualitative probability
Dam type	ice (inside the dam)	high
	moraine	medium high
	bedrock	low
Freeboard relative to dam (vertical distance between the water level and top of the dam)	low	high
	medium	medium
	high	low
Dam height to width ratio (Narrowness of the dam)	large	high
	medium	medium
	small	low
Impact waves by ice/rock falls reaching the lake	frequent	high
	sporadic	medium
	unlikely	low
Extreme meteorological events (high temperature/ precipitation)	frequent	high
	sporadic	medium
	unlikely	low

Source: RGSL (2003)

Assessing hazard

Hazard assessment as a process includes determining the hazard level scale by combining the hazard intensity based on the hazard intensity scenario, and the hazard probability level. An example of a hazard level scale is shown in Figure 4. The hazard probability level consists of four levels (very high, high, medium, and low) and the hazard intensity level of four degrees (high, moderate, moderately, low). In the resulting hazard level scale (4 x 4 = 16 cells), 4 different levels are identified (very high, high, moderate, and low).

Figure 4: **Hazard level scale**



It is common to present hazard levels in the form of hazard maps. But be sure to verify the conditions portrayed in the hazard maps with actual field conditions. Hazard maps can be prepared with community involvement. For best results, combine the technical hazard intensity maps with the community-based hazard maps. An example of a flood hazard map is shown in Figure 5.

Step 3: Assessing vulnerability

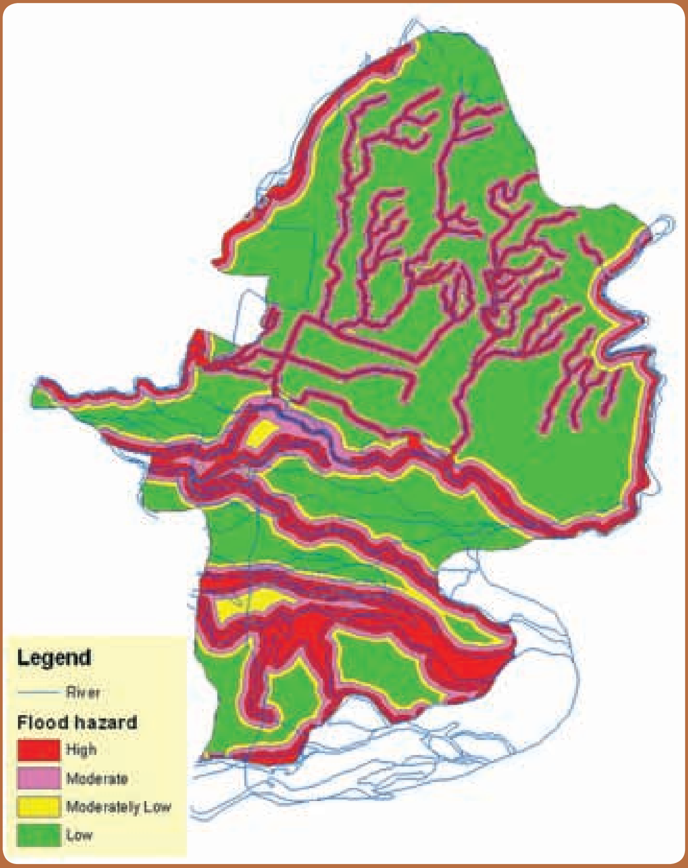
After assessing and identifying that a hazard exists, the next step in risk analysis is assessing vulnerability. This means looking at the characteristics of the receptor – the community, houses, or people – at the receiving end of vulnerability. Here we present an approach which combines physical vulnerability with social response and action (Cutter 1996, Messner and Meyer, 2005).

Assessing physical vulnerability

How physically vulnerable people and infrastructure are is expressed as a vulnerability index or measure and depends on susceptibility and exposure to hazard.

Susceptibility. Susceptibility to flash floods is the state of defenselessness to it. A high susceptibility, has the potential to endanger or lose lives, property, ecological species, and landscapes. Generally, higher value elements are assigned a higher vulnerability index. For example, people's lives have a higher value over property.

Figure 5: **A simple flood hazard map of Bhandara Village Development Committee, Chitwan, Nepal**



Exposure. The measure of vulnerability (vulnerability index) depends on the amount of exposure to flash flood risk. An exposure indicator depends on how far the receptor is from the source of the hazard (for example, distance from or height above a river source of a flash flood). Exposure can be described as high, moderately high, moderate, and low, which constitutes a (qualitative) description of level of exposure.

It is difficult to quantify or measure exposure of several elements at risk, such as people's lives, or that of ecological species, or landscapes, and therefore a vulnerability index has to be based on qualitative or described categories. A general guideline for assigning vulnerability level for different land use categories are given in Table 4.

Table 4: **Vulnerability level scale as a function of land use category**

Category	Vulnerability level
Natural areas (natural water courses, unproductive areas, etc)	Low
Agriculture and forestry (meadows, pastures, forests, etc)	Moderately low
Special agriculture (fields, orchards, etc)	Moderately low
Trade and industry	High
Local infrastructure (trails, secondary roads, tertiary canals, etc)	Moderately low
National infrastruture (main roads, railway lines, main canals, etc)	High
Settlements, mosques	High
Special objects (power stations, cultural heritage sites, strategic facilities, etc)	High

Source: RGSL (2003)

Assessing socioeconomic vulnerability

The capacity of a society in a physically vulnerable zone to adapt to flash flood or disaster risk determines socioeconomic vulnerability. Adaptive capacity of a society itself is a function of social and economic processes. New settlements along river banks or flash flood debris fans are a good example of processes that increase vulnerability to flash floods. Poverty and limited availability of land are governing factors behind this. Communities with access to communication, financial institutions, and markets, and have diversified income sources have stronger adaptive capacity and are hence, less vulnerable. Adaptive capacity can be expressed in terms of numbers (quantitative) or subjective description (qualitative). The list of quantitative indicators is given in Table 5 (Shrestha 2005); the qualitative indicators are listed in Table 6. In practice, combinations of quantitative and qualitative indicators should be used in assessing socioeconomic vulnerability.

Table 5: **Quantitative and qualitative indicators**

Parameter	Quantitative indicators
Accessibility	Road density (m/km^2)
Health	Number of health institutions/1000 population
Communications	Number of telephones/1000 population
Institutions	Number of GOs and NGOs/1000 population
Economic	Number of financial institutions/1000 population
Loss-sharing measures	Value of revolving fund (disaster fund)
Economic diversity	Percentage of families with a number of income sources

Source: Shrestha (2005)

Physical and socioeconomic vulnerability are combined to obtain the total vulnerability, which might again be presented as qualitative categories (e.g. high, moderate, moderately low, low, etc.).

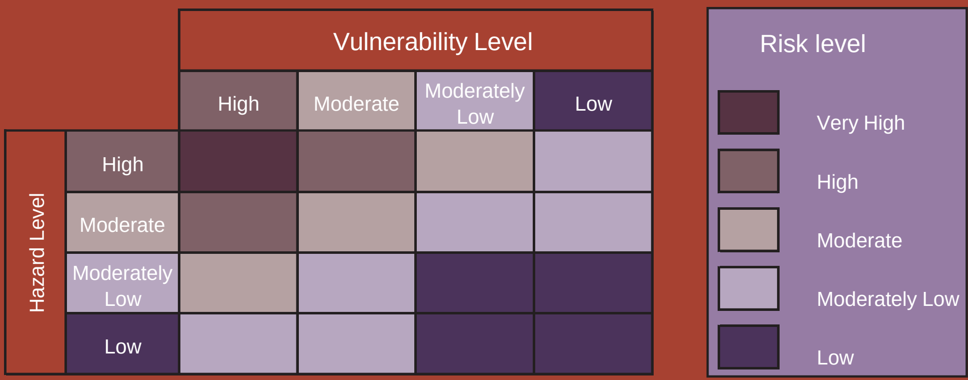
Table 6: **Qualitative indicators**

S.No.	Indicator
1.	Emergency facilities
2.	Warning system
3.	Loss reduction measures
4.	Awareness and attitude

Step 4: Assessing Risk

A risk level scale is a combination of both physical and socioeconomic hazard levels and total vulnerability level. Like the hazard level scale, the risk level scale is obtained using subjective judgment. Figure 6 shows the risk level scale that can be used to assess flash flood risk. Four levels of hazard and four levels of total vulnerability (high, moderate, moderately low and low) are considered here. The resulting risk level scale consists of 4 x 4 = 16 cells and may be classified in to five different risk levels: very high, high, moderate, moderately low, land low.

Figure 6: **Classification of risk level**



Resources needed

The following resources are necessary to be able to conduct risk assessment.

1. Technical and professional staff (for example, Ministry of Energy and Water central and provincial levels)
2. Community and local government authorities for the collection of information related to characterising the area

3. GPS and other devices to add spatial dimension to the information collected
4. A system for storing collected information
5. A geographic information system (GIS) for the graphical representation of maps and spatial analysis. Depending on the resources and capacities available, a simple community-based mapping approach can be adopted
6. A set of computer programmes for processing data such as hydrological and hydraulic models. A simple alternative can be a social hazard mapping of past floods and damages. Even if complicated computer softwares are used, the results should be verified by field investigation involving community members.

Conclusion

The methods presented in this section are some of many available in the literature on flash flood risk. They combine several methods or methodologies and may be modified, even simplified according to the specific conditions, resources, capacities, and available data in Afghanistan. In terms of spatial scale the method described can be adopted to the macro (provincial), meso (district), and micro (garia or village) levels, although, the approach described will be more effective at meso and micro levels. Each intermediate step in risk assessment results in different maps:

- a hazard intensity map,
- a hazard level map,
- a vulnerability (physical and socioeconomic), and
- a risk map.

Each of these map outputs have their own importance in flash flood risk management, particularly in the selection of structural or non-structural measures or combination of measures. While combining two outputs to derive secondary outputs (e.g., hazard and vulnerability levels to derive risk levels, an appropriate weighing factor can be used.) The outputs can be expressed in money terms, which can be a firm basis for feasibility study of intervention measures.

For Further Reading

Azizi, PM; Naimi, Q (2006). Status report of flash flood events and mitigation management in Afghanistan in Xu, J; Eriksson, M; Ferdinand, J; Merz, J (Ed) 'Managing flash floods and sustainable development in the Himalayas', proceedings of the International workshop on flash floods management and sustainable development held in Lhasa, Tibet in October 2005 pp. 81

Colombo, AG, Havás, J; Vetere Agnello, AL (2002) Guidelines on flash flood prevention and mitigation. EUR 20386 EN, Luxembourg: European Commission Joint Research Centre

UN/ISDR (2002) Guidelines for reducing flood losses, United Nations/International strategy for disaster Reduction. www.unisdr.org. Geneva: UN/ISDR

References

Colombo, AG, Hevas, J; Arllam, ALV (2002) *Guidelines on flash floods prevention and mitigations*. Ispra (VA) Italy: NEIDES

Cutter, SL (1996) *Vulnerability to natural hazards*. Progress in Human Geography, 20, pp529-539. Available at sagejournalsonline, http://phg.sagepub.com/current_dtl

Gouldby, B; Samuals, P (2005) *Language of risk, wallingford, flood site*. Oxfordshire (UK): Floodsite project, Floodsite Consortium

Messner, F; Meyer, V (2005) Flood damage, vulnerability and risk perceptions – challenge for flood damage research, Leipzig, UFZ-Umweltforschungszentrum Leipzif-halle: Helmholtz Centre for Environmental Research

RGSL (2003) 'Methods of glacier and lake inventory compilation with specific reference to hazard assessment', Flintshire: Reynolds Geo-sciences Ltd, UK

Shrestha, A (2005) Vulnerability assessment of weather disasters in Syangja District, Nepal: A case study of Putalibazar Municipality, advanced institute on vulnerability to global environmental dhange/global change system for analysis research and training. Kathmandu: START and Department of Hydrology, Nepal