SRC International Cooperation

Flood Hazard Analysis

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Description of working steps for flood hazard analysis

Advanced standard

Swiss Red Cross

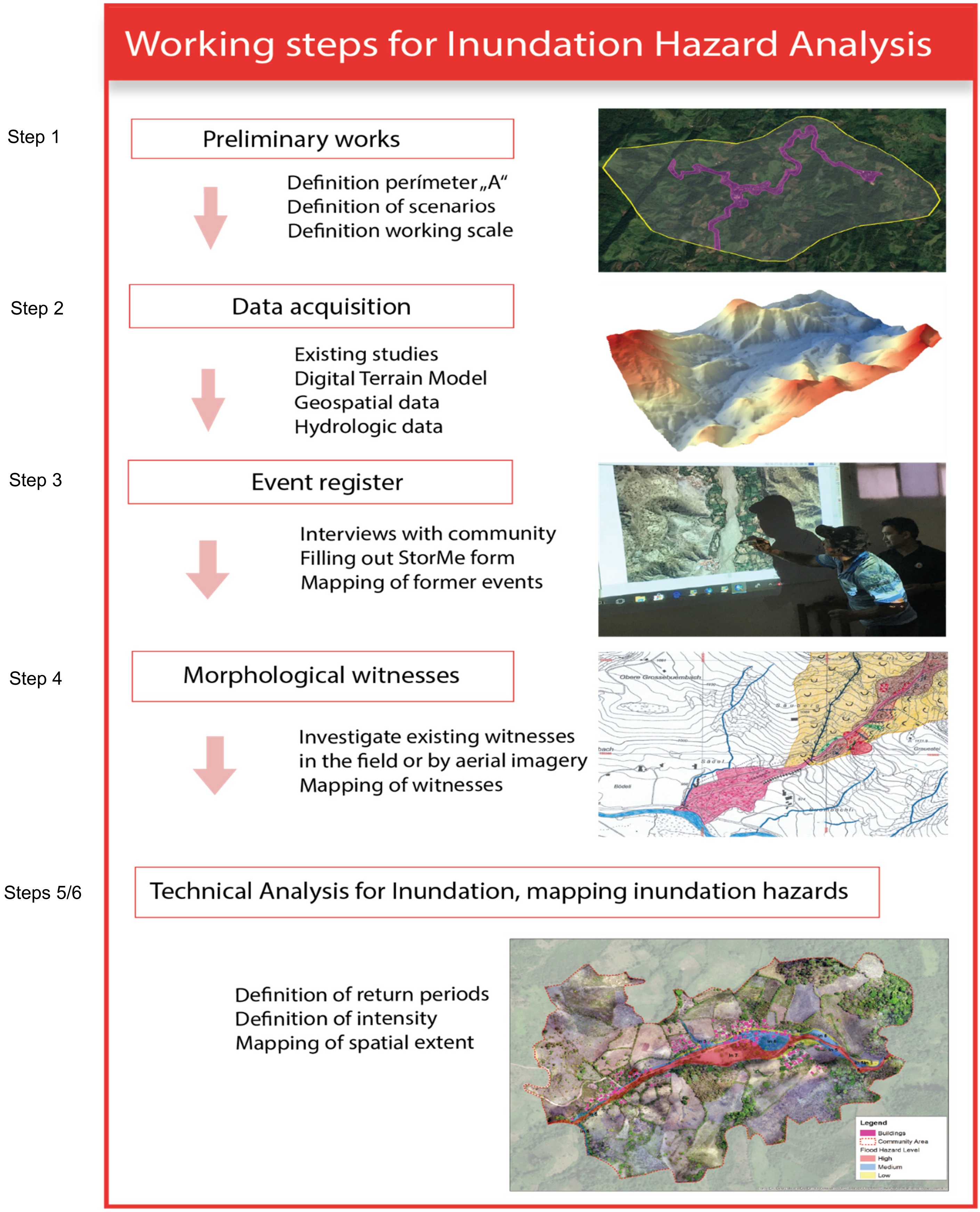


Illustration 1: Working steps for the analysis of flood hazards. Source: SRC.

Step 1 – Preparatory work

Definition of the perimeter and detail level of the analysis

Before starting a hazard analysis, the study area should be spatially defined and captured on a map. As a general rule, the perimeter of a hazard map is smaller than the project area and includes areas for settlements, infrastructure facilities and important livelihoods. Therefore, the perimeter of the hazard mapping must be limited to these areas (perimeter "A"). By limiting the perimeter to relevant areas, it is possible to save time and costs. Areas outside this borderline should also be explored if they affect this perimeter. Illustration 2 shows the project area (in yellow) and perimeter "A" of a hazard mapping (in purple). Perimeter "A" is defined jointly by the communities and competent authorities. In tenders for hazard mapping, perimeter "A" must be defined in the terms of reference. The detail level of the analysis must also be determined. Scale accuracy between 1:5,000 and 1:10,000 is appropriate for land use and mitigation measure planning at the municipal level.

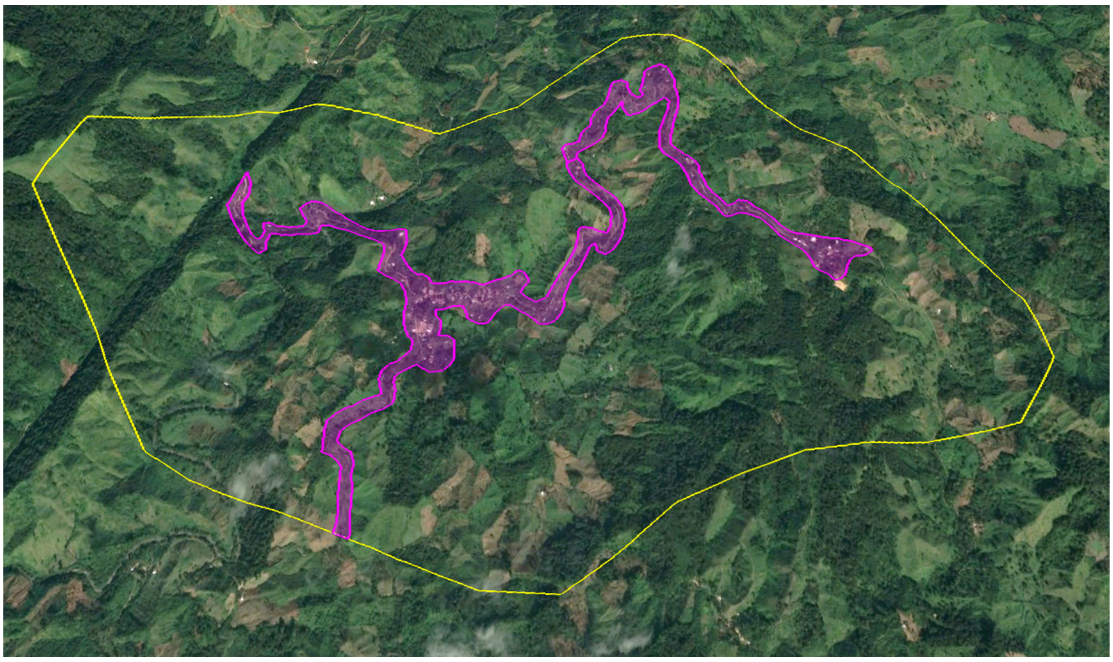


Illustration 2: Drawing of a project perimeter (yellow area) and perimeter "A" of a hazard map (purple area).

Definition of scenarios

The scenarios for the study (return periods to research) are usually specified by the authorities. If no specifications exist, it is recommended to consider three research scenarios, which are often applied with return periods of 10, 30 and 100 years, equivalent to a very frequent event, a generational event and an extreme event, respectively (see table 1). Typically, hazards from frequent and, sometimes, generational events can be reliably determined with the minimum standard. To determine an extreme event hazard, it is advisable to apply the advanced standard, as in a normal situation there is lack of information on events that have occurred within this scenario.

Table 1: Scenarios and their return periods. Source: SRC.

Type of event	Frequent event	Generational event	Extreme event
Name of scenario	„10-year“	„30-year“	„100-year“
Return period	≤ 10 years	10 – 30 years	30 – 100 years

Step 2 – Baseline Data Collection

Baseline data provide valuable information on past events and their extent, return period and intensity. The quality of a hazard analysis relies primarily on the availability of baseline data. The following are some baseline data:

- Topographic map or satellite photos as cartographic base
- Reports and studies from previous events (VCA, etc.)
- Photos of events and damage occurred
- Georeferenced aerial photos from different dates
- Digital Terrain Model (DTM)
- Digital drainage system
- Watercourse geometry (longitudinal and transversal profile measuring)
- Precipitation records
- Registers of historical discharge values
- Digital documentation of land and soil use
- Studies of works and previous hazard studies

Step 3 – Event Register

The analysis of past events is a core component of a hazard analysis. Particularly for very short return periods, the information obtained may be sufficient to describe a hazard in the relevant scenario. For scenarios with long return periods (extreme events), data serve to verify the results of technical analyses. The documentation process of these events allows for taking into account the local population's knowledge on natural hazards. It also serves to raise awareness and help the population to take ownership of the hazard map.

The IFRC's VCA methodology describes methods and tools to collect information from past events in a participatory manner. Particularly interesting is the frequency and spatial extent of the debris flows occurred. In addition, the observed flow height of debris flows [m] should be mapped at as many locations as possible and recorded using the StorMe form (Annex 1). Two pragmatic approaches are presented below:

Aerial Photo-based Approach

- A facilitator projects an aerial photography of the perimeter of interest (GoogleEarth) on a white paper (Illustration 3).
- Through an exercise with the plenary, the facilitator ensures that all participants can orient themselves using aerial photography.
- In a participatory procedure, the spatial extent of previous events is marked on the white paper. Each event area is assigned with the date of the related event and the type of hazard process (event index). This is linked to the StorMe forms (Annex) attached to each documented event.
- In the plenary, known damage and event information are compiled into the StorMe form. For this, the facilitator appoints someone who has previously become familiar with the form so that he/she can be responsible of the protocol. The StorMe form is referenced with the event index on the photo displayed.

Illustration 3: Mapping carried out by the population on areas affected by previous events (Poco Poco, Bolivia). Source: SRC.

"Field Tour" Approach

After a meeting with community representatives or when participants cannot orient themselves with an aerial photo, they are invited to tour the area of interest. The information collected in the field about events occurred is entered into the StorMe form. The places where there is information about the intensities of the events occurred are marked (see Table 4) and recorded on a map.

Illustration 4: A woman points out the water height after a flood event in Los Amates, Honduras. Source: SRC.

Step 4 – Collection of Flood Evidence

By walking along the banks of the watercourse, we look for flood traces or silent witnesses, as shown in Table 1. These are mostly traces of sediment or garbage hanging on branches near the river. Documenting and interpreting these witnesses in the field will lead to similar conclusions about future floods in terms of their possible spread, intensity and frequency of occurrence. Evidence collection is mainly carried out through on-site inspections but can also be complemented with information from aerial photographs.

Table 2: Morphological phenomena that are characteristic of floods.

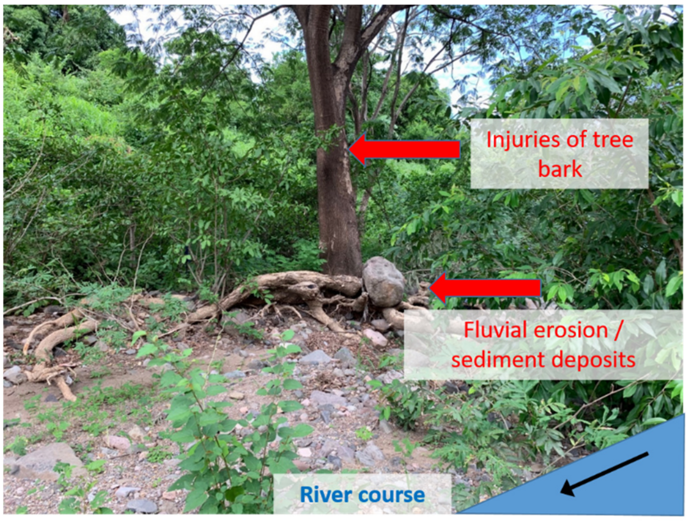
Description	Illustration
Illustration 5 Traces of flood events on vegetation. Source: SRC.	
Illustration 6: Traces of flood events on vegetation. Source: SRC.	
Illustration 7: Branches hanging from a bush near the river. Source: SRC.	

Illustration 8: Aerial view of a watercourse. The lighter areas show traces of flows and sediment deposits from previous events.

Source: COSUDE Haiti.

Illustration 9: Braided traces of old flows in a torrent cone, caused by frequent flooding.

Source: Helvetas Intercooperation Bolivia.

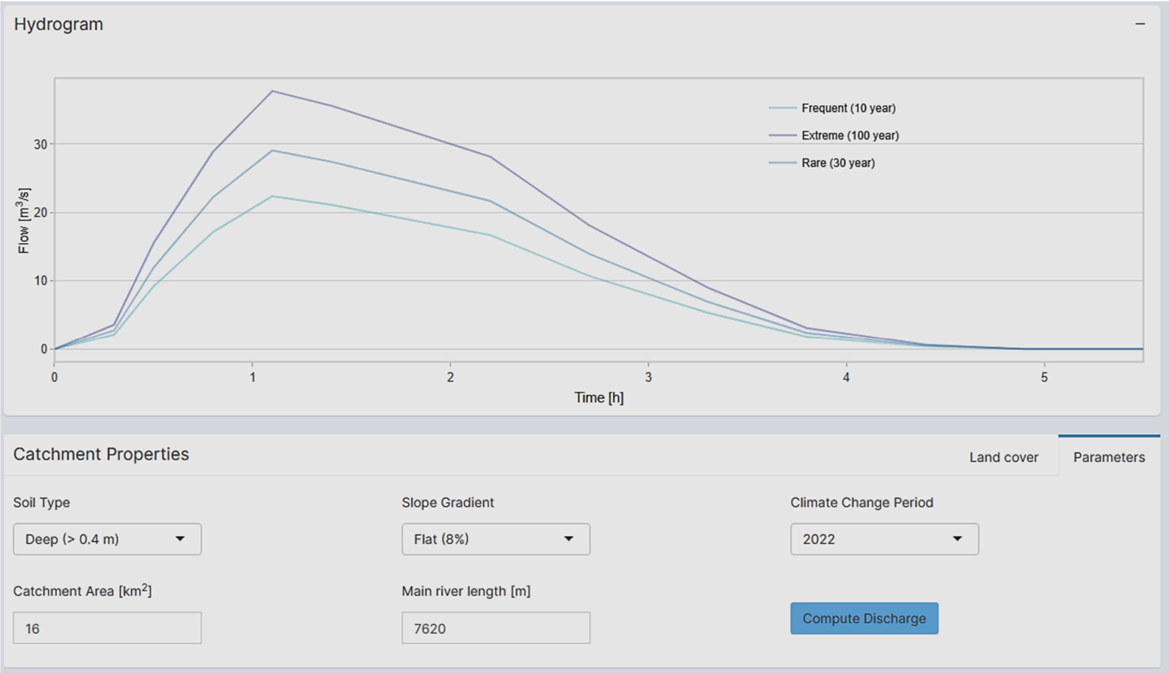
As with the morphological phenomena for landslide or debris flow processes, the traces of the "flood" process will be mapped on a topographic map or satellite photograph, according to the Annex.

Step 5 – Technical Analysis of Floods

A technical analysis involves the calculation of peak flows for the three defined scenarios (frequent event, generational event and extreme event) and the comparison of peak flows with the discharge capacity of the watercourse. An overflow is expected to occur when the peak flow exceeds the discharge capacity at a point along the watercourse. When applying the advanced standard, the effect of driftwood and sediment in the basin must also be considered, which can manifest itself in obstructions and flashfloods in the "A" perimeter (see chapter 5.3).

Step 5.1: Estimation of the peak flow for different scenarios

This guideline provides the model AUGUR Discharge (https://augur.world/discharge/). AUGUR Discharge is a hydrological model for quantifying flood discharges with different return periods. It is based on the SCS methodology and requires basic data such as drainage area, runoff factor, time of concentration and rainfall. The input data for precipitation are taken from the AUGUR-Precipitation application (www.augur.world). The model is used for catchment sizes between 5 - 300 km^2. The model calibration was performed on a total of 40 measured catchments in Switzerland and Chile. AUGUR Discharge is the result of a collaboration between SDC, Swiss Red Cross and the University of Bern.



Step 5.2: Calculation of the discharge capacity

By comparing the peak flow value (for each scenario) with the discharge capacity at different points along the watercourse, it is possible to determine critical points with potential overflows. To calculate the discharge capacity at a particular interest point, it is necessary to measure the cross-sectional area of the watercourse in m^2 and approximate the runoff velocity at this point. The product (multiplication) of the runoff velocity [m/s] and the cross-sectional area [m^2] represents the maximum discharge capacity [m^3/s] of the watercourse at the point of interest. The following method is provided to calculate the runoff velocity:

a) Measurement of the cross-sectional area of section "A" (Illustration 10) in m^2
b) Determination of velocity (v) in m/s in function of watercourse roughness (k), hydraulic radius (R) and watercourse slope (J) according to

$$v = k * R^{0.66} * J^{0.5}.$$

The longitudinal slope of the watercourse (%/100) is measured with an inclinometer or in a GIS. The roughness factor "k" is determined as recommended in the Annex of this guideline. The hydraulic radius (R) corresponds to the cross-sectional area in relation to the (wet) circumference "U" of the watercourse, according to Illustration 10.

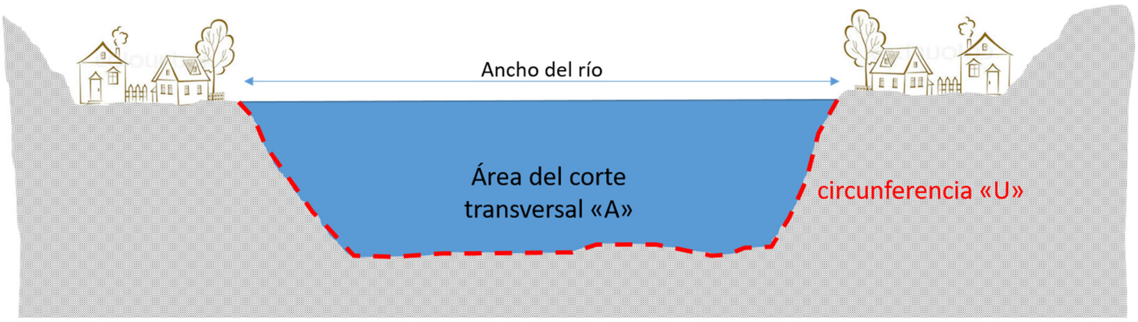


Illustration 10: Schematic cross profile. The blue area multiplied by the runoff velocity equals the maximum discharge capacity of the river. The circumference "U" for the determination of the hydraulic radius is presented in dashed red. Source: SRC.

AUGUR (https://www.augur.world/home/) provides an Excel sheet that can be used to determine the hydraulic discharge capacity. It is also possible to define for each point of interest along the watercourse from which scenario water outflows and thus flooding can be expected. The influences of alluvial wood and bed load must be assessed separately.

Step 5.3: Potential clogging

Bridges and sewers can cause clogging when sediment and driftwood are transported during floods. The probability of clogging can be examined using the criteria in Table 3. Instead of return periods of 10, 30 and 100 years, the table considers "very frequent", "occasional" and "extreme event" scenarios.

Table 3: Decision criteria for estimating the frequency/probability of clogging.

Availability of driftwood and garbage	Prone to slope-type mud flows	Documented cloggings		Obstacles to the flow (bridges)		Clogging
- Frequently, driftwood and garbage are observed in the watercourse. - Heavily forested embankments	High in a long reach of the river	At least 1 event documented in the last 10 years	+	- The bridge reduces the cross profile of the watercourse. - Bridge with central pillar - Considerable morphological narrowing of the watercourse	=	Very frequent
- No driftwood or debris is observed in the watercourse. - Heavily forested embankments	Medium	1 event documented in the last 10-30 years	+	- Bridge without narrowing of the water course - Morphological narrowing of the watercourse	=	Ocasional
Forested embankments, the watercourse is wide and can be appropriately distinguished in satellite photos	Low	Not documented	+	- Bridge without narrowing of the watercourse	=	Extreme event

Step 6 – Elaboration of a Hazard Map

Based on the information collected, a map is drawn up for each defined scenario (return period of 10, 30 and 100 years) showing the spatial extent and intensity of future floods with the relevant frequency of occurrence. From the points of possible flow, an expert follows the possible flood trajectories and records the flood-prone areas on a map. Alternatively, a two-dimensional hydraulic model can be applied to define potential flood areas (HEC-RAS 5, Hydro_AS-2D and others).

As a result, three maps are obtained which differentiate flood intensities (low, medium and high) as shown in

Table 4 and Illustration 2 in "Documentation of results”. These three maps are merged in order to obtain a single flood hazard map. The "Documentation of results" describes the process of merging the maps.

Table 4: Differentiation of flood intensity. h stands for flowheight, v stands for flow velocity

	Intensity		
	Low	**Medium**	**High**
h [m]	< 0.5	0.5 – 2.0	> 2.0
h*v [m^2/s]	< 0.5	0.5 – 2.0	> 2.0
People affected	No harm out of buildings	Danger of drowning out of buildings	Danger of drowning inside and outside of buildings
Assets affected	Minor non-structural damage	Significant damage	Destruction or structural damage

Examples of flood intensities

Illustration 11: Low intensity flood. Adults can cross the flooded sector without risk of being swept away.

Illustration 12: Medium intensity flood. Vehicles may be swept away due to flow velocity and depth.

Illustration 13: High intensity flood. Buildings can be destroyed and washed away.