MANAGEMENT OF NATURAL HAZARDS
IN MOUNTAIN BASINS

Mitigation measures against natural risks

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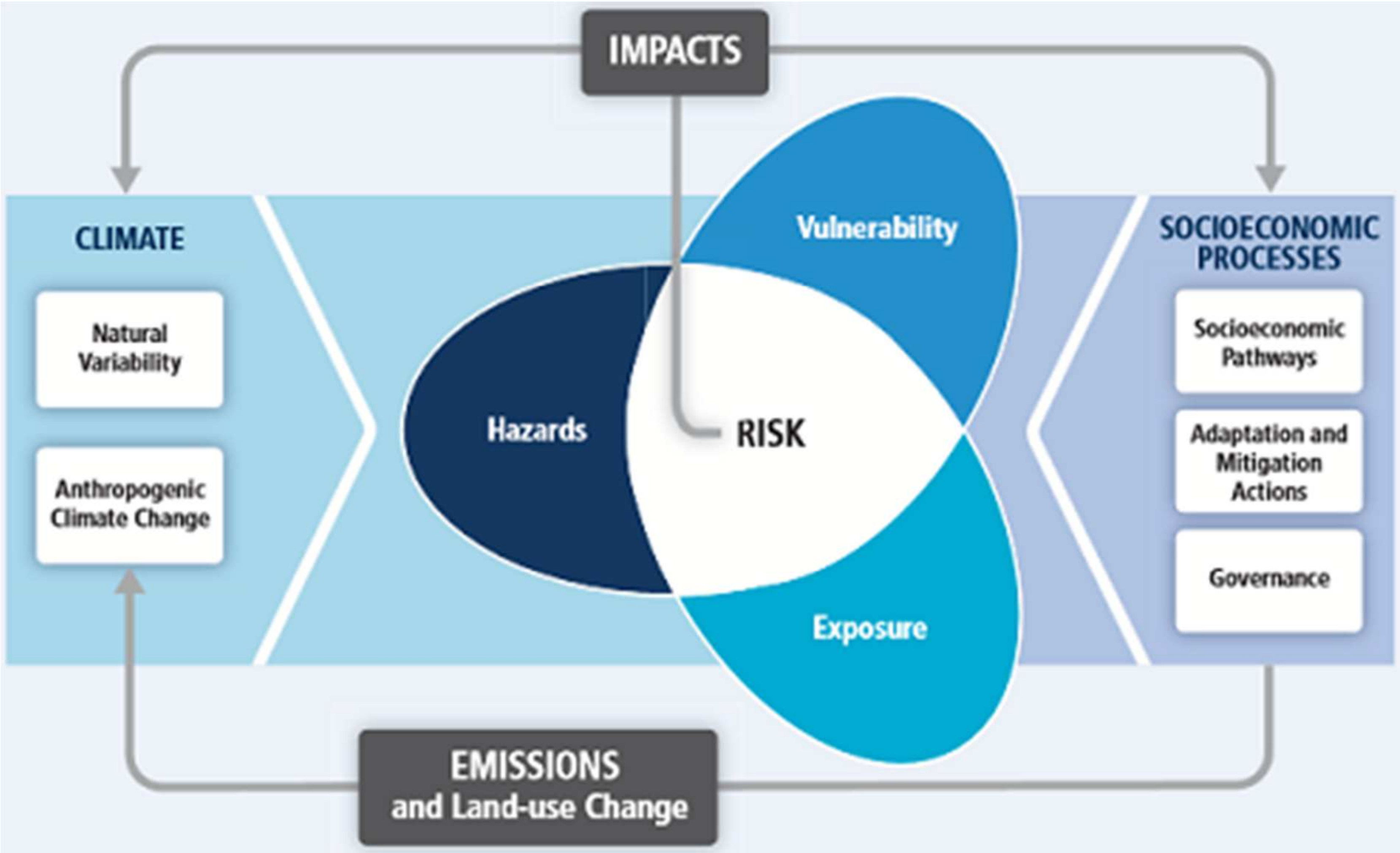
Recalling what risk is…

Risk = Hazard x Exposure x Vulnerability



…the possible mitigation measures

- Reduction of hazard
  - ➢ Traditional approach
  - ➢ Expensive
  - ➢ Effectiveness ? (design scenario)
  - ➢ Environmental disadvantages

- Reduction of exposure
  - ➢ The ideal solution (theoretically)
  - ➢ Socially difficult (when feasible)
  - ➢ Still few examples realized
  - ➢ Key for still undeveloped areas

- Reduction of vulnerability
  - ➢ Potentially very effective
  - ➢ Incresingly applied
  - ➢ Physical easier than social
  - ➢ «adaptation» to hazards

Structural vs non-structural measures

Hazard mitigation

- Mostly through structural measures

- Aims to reduce *event intensity* (flow depth/velocity/pressure; deposition depth; rock size/energy) for a range of recurrence intervals

- Based on the concepts of:

  - Prevent or decrease transport processes
    (in initiation or transport zones)

  - *Retaining volumes* upstream of vulnerable areas
    (in transport zones)

  - Increase *conveyance* within vulnerable areas
    (in transport and depositional zones)

Hazard mitigation

- Preventing transport processes in initiation areas

Avalanche barriers (foto SLF Davos)

Rockfall protection nets

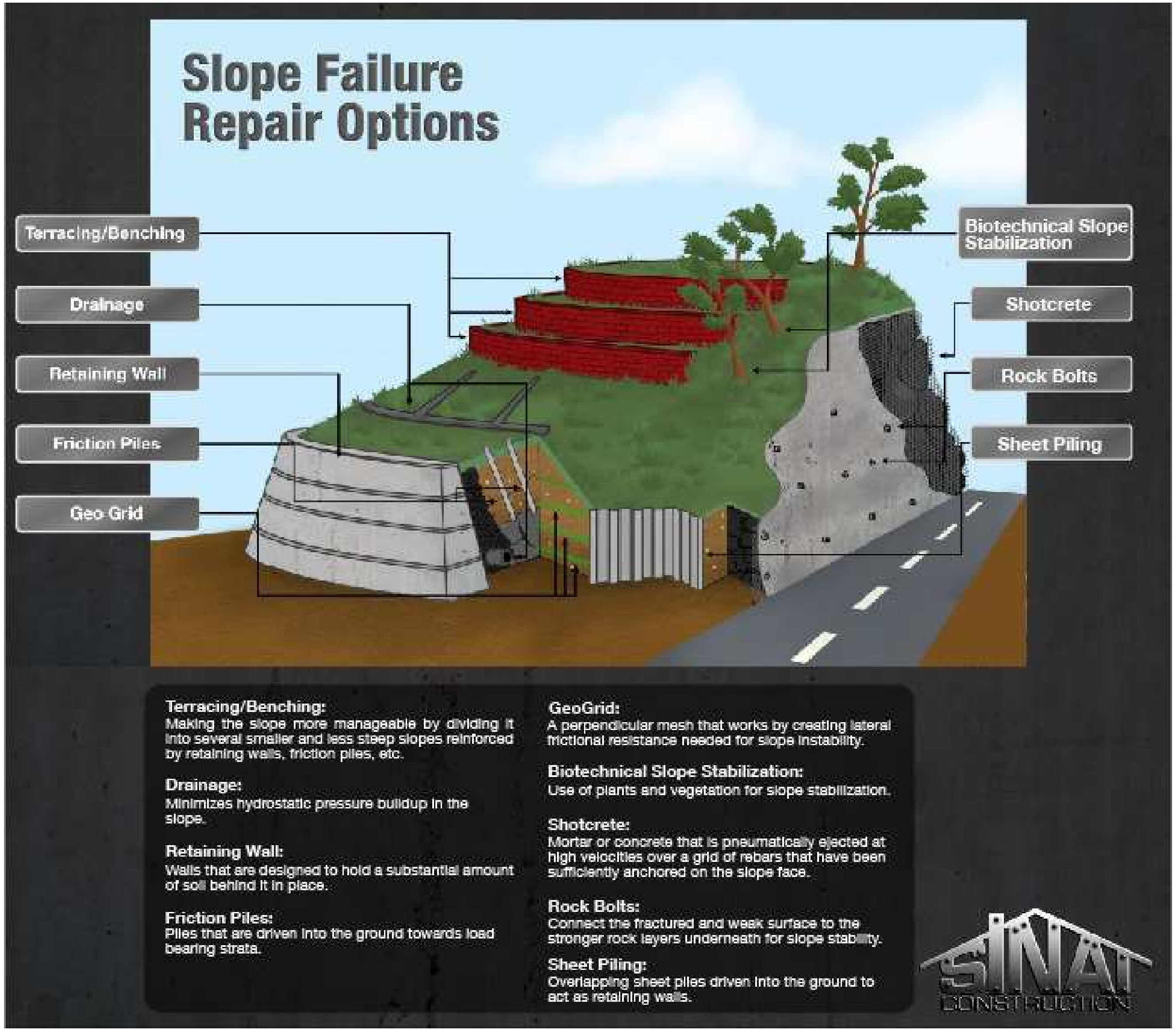
Consolidation check-dams (Foto Studio Archeng)

Hazard mitigation

- Preventing landslide initiation

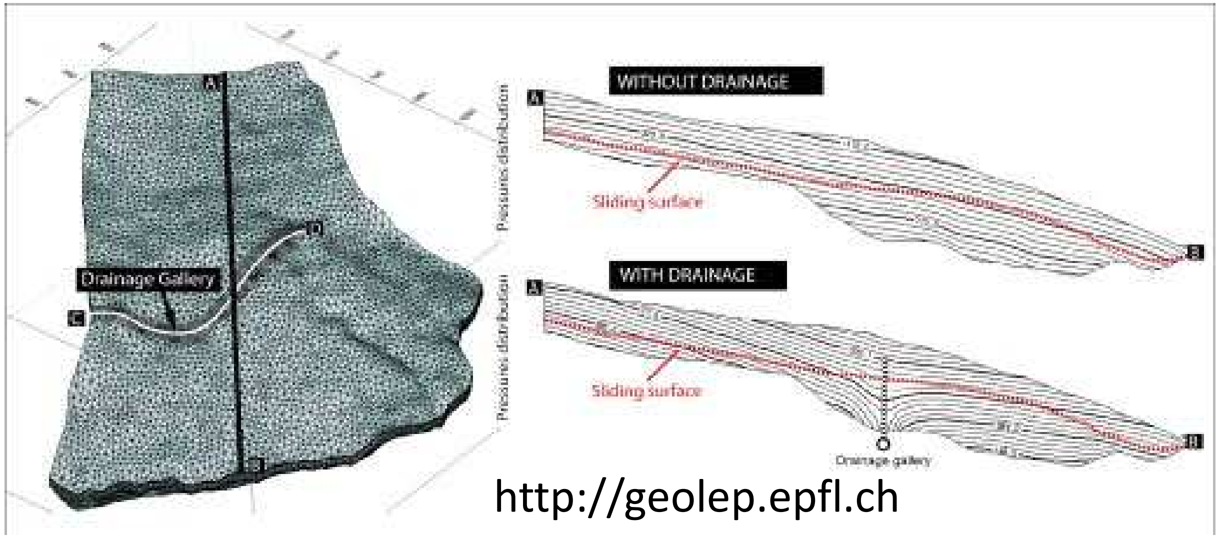
Slope safety factor increased by:

- Reducing pore pressure (drainage, vegetation)
- Increasing cohesion (drainage, vegetation)
- Increasing stabilizing forces/moment (concrete/metal structures)

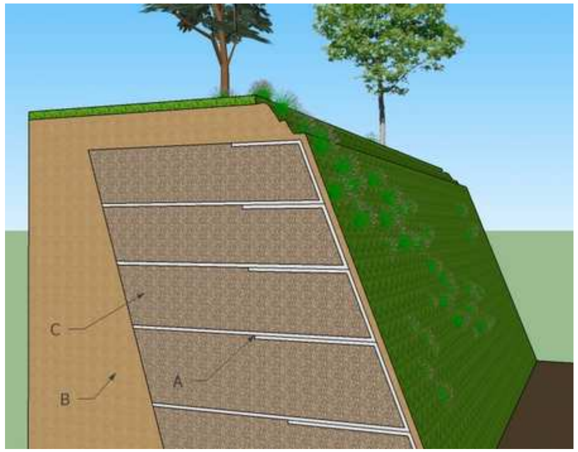


Hazard mitigation

- Preventing landslide initiation



http://geolep.epfl.ch



www.ecofibre.it

Hazard mitigation

- Reducing transport processes in transport zones

Rockfall barriers (photo Geobrugg)

Rockfall retaining wall
(www.ingph.eu)

Avalanche retention barrier
(www.eagm.eu)

Hazard mitigation

- Reducing transport processes

Reduce flow velocity

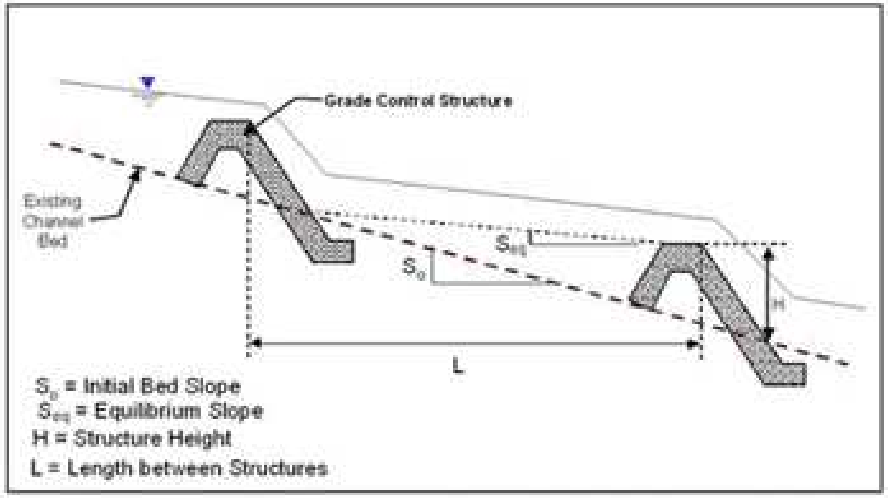
↓

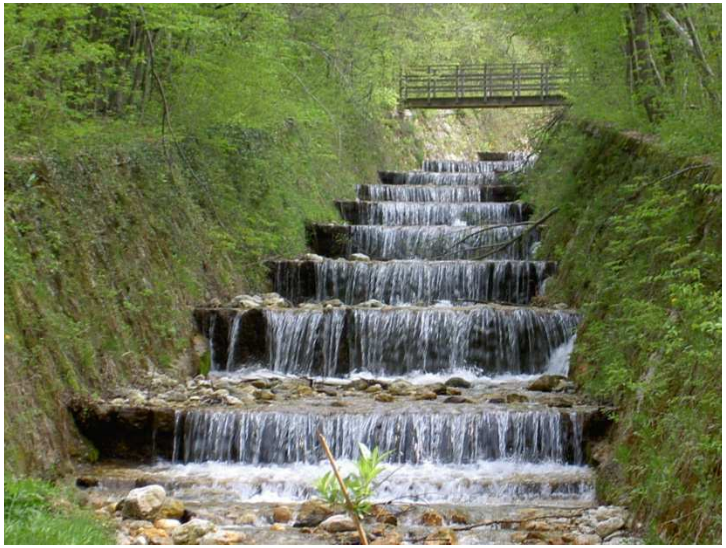
Reduce energy/bed slope

↓

Create stable drops in the long. profile (grade-control structures)

➢ consolidation check-dams and bed sills





Hazard mitigation

- Reducing transport processes in the transport zone

Reduce bank/hillslope erodibility

Heavy/resistant boundary

Bank protections

- ✓ Concrete walls
- ✓ Large rocks (riprap) with or without cement
- ✓ Large wood elements (engineered wood jams)

Hazard mitigation

- Retaining volumes upstream of vulnerable areas

To reduce flood peak discharges

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Store temporarily part of flood runoff

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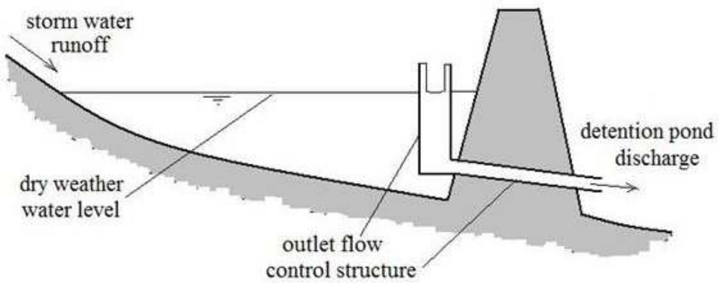
- ✓ Flood retention/detention basins
- ✓ Multipurpose dams (including flood attenuation)
- ✓ Allow valley floor flooding (where not urbanized…hard !)



Hazard mitigation

- Retaining volumes upstream of vulnerable areas

To reduce sediment and wood volumes transported by a flood

↓

Trapping sediment and wood during the event in retention basins

↓

✓ *Retention check-dams*

(fill up quickly ! High maintainance costs)

✓ *Filtering check-dams*

(trap only coarse bedload + wood, self-cleaning ?)

✓ *Steel nets /ropes*

(for wood only)

Hazard mitigation

How much filtering ?
The self-cleaning design

Hazard mitigation

- Retaining volumes upstream of vulnerable areas

To stop debris flow propagation

↓

Breaking and trapping debris flow fronts

↓

- ✓ *Concrete/steel debris-flow check-dams*
- ✓ *Debris flow ring nets*

(photo Geobrugg)

Hazard mitigation

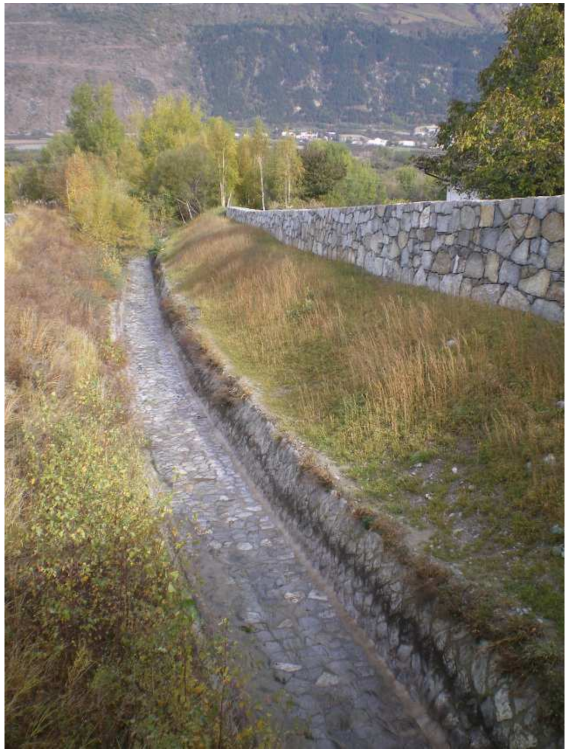
- Increase conveyance within vulnerable areas

Increase flow velocity
(stabilizing bed)

Reveted channel, narrow sections

Hazard mitigation

- Increase conveyance within vulnerable areas



Prevent water or debris flows
from flooding adjacent land
(floodplain, fans)

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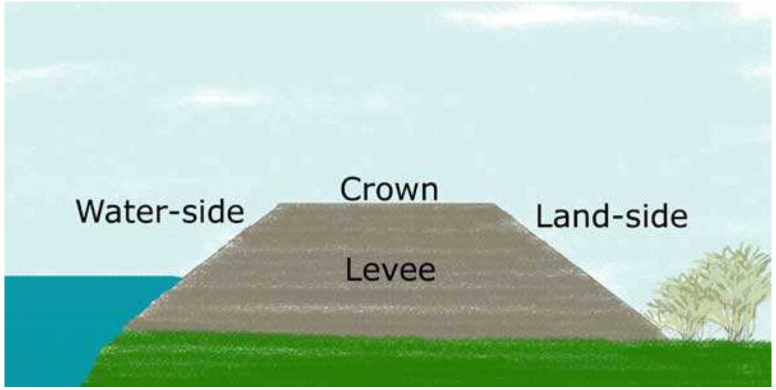
Levees



Flood hazard mitigation in the Alps: evolution

- **16th – 19th century**

Masonry (retention)
check-dams

- **19th century – 1940s**

Slope and channel wooden
consolidation structures

- **1960s – 1980s**

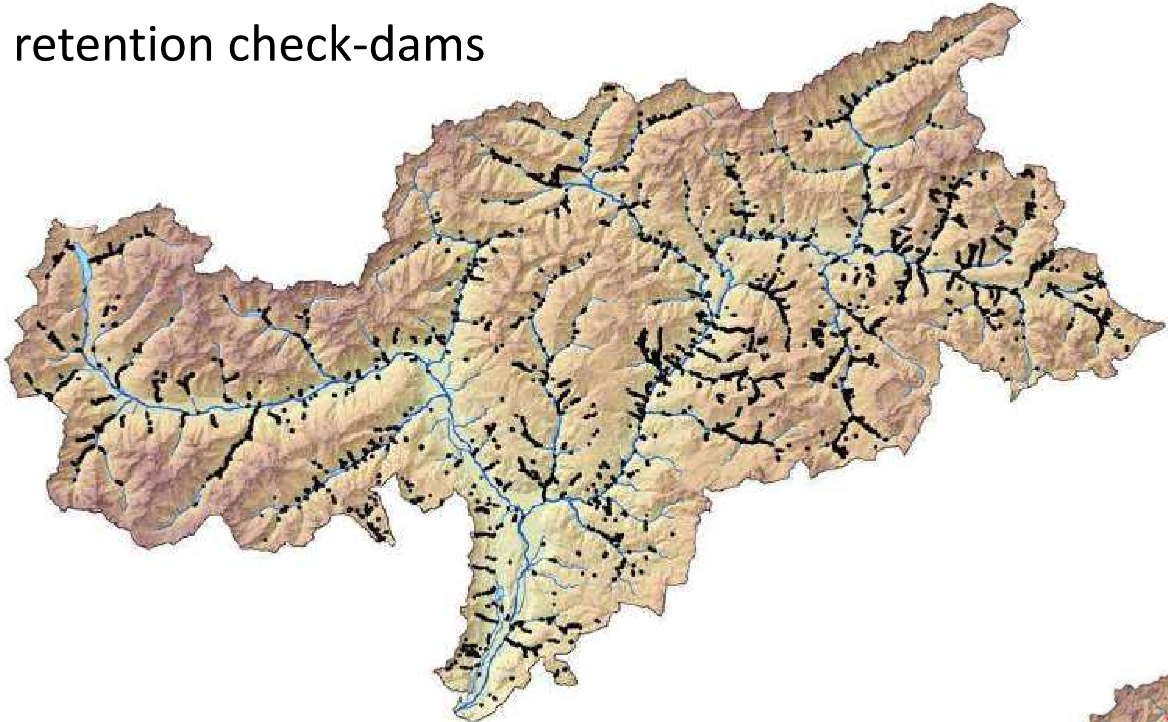
Concrete consolidation and
retetion check-dams

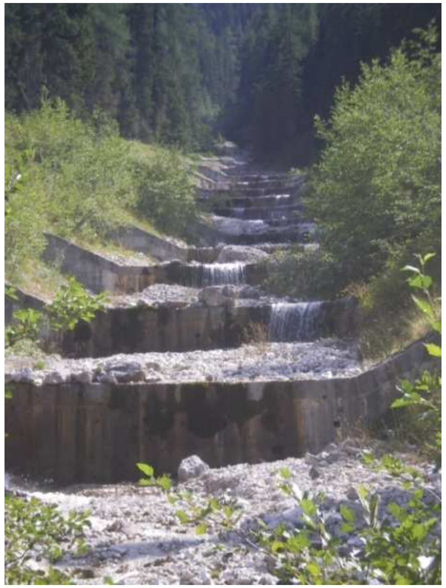
- **1990s – now**

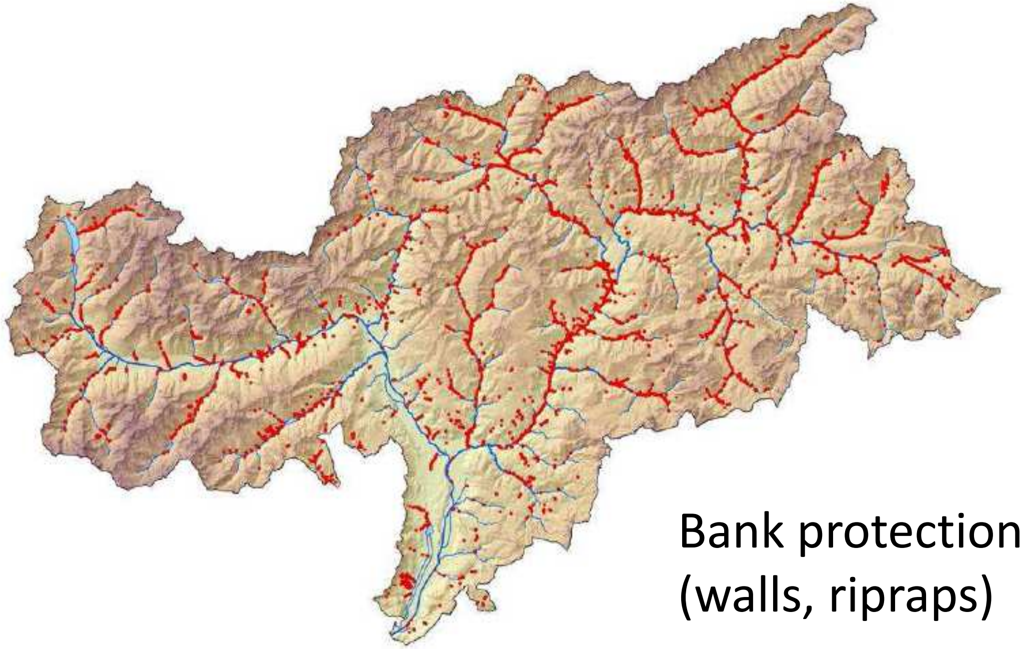
Concrete/steel filtering check-dams and
Boulder/wood check-dams/ramps for consolidation

Flood hazard mitigation in South Tyrol

About 64000 consolidation and retention check-dams



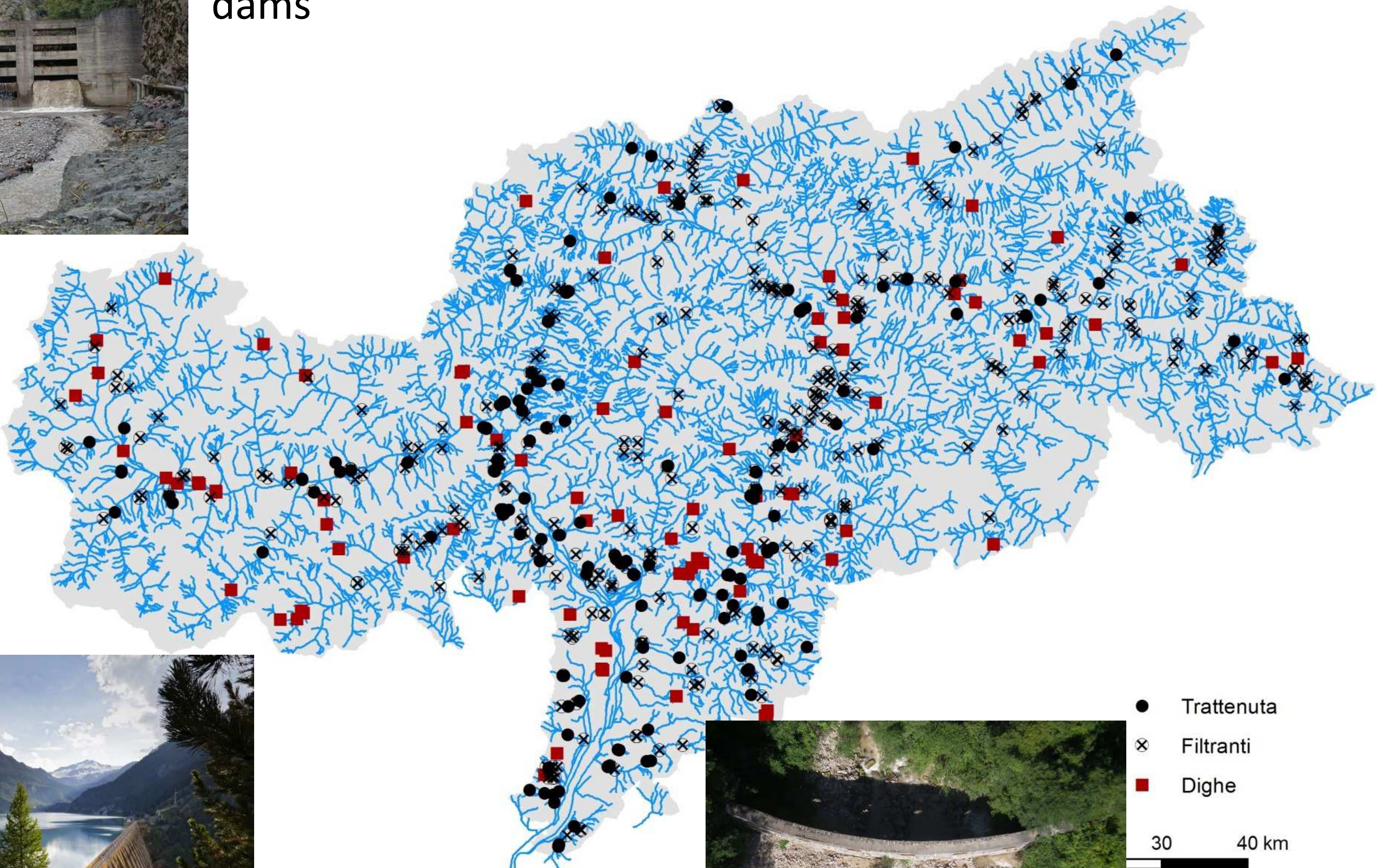




Bank protections (walls, ripraps)

South Tyrol: sediment disconnections

Filtering (open) check-dams



Dams

Retention check-dam

Structural measures and their risks !

Levees and check-dams failure are commonly observed during extreme events

Structural measures

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«safety feeling»

↓

construction in potentially hazardous areas

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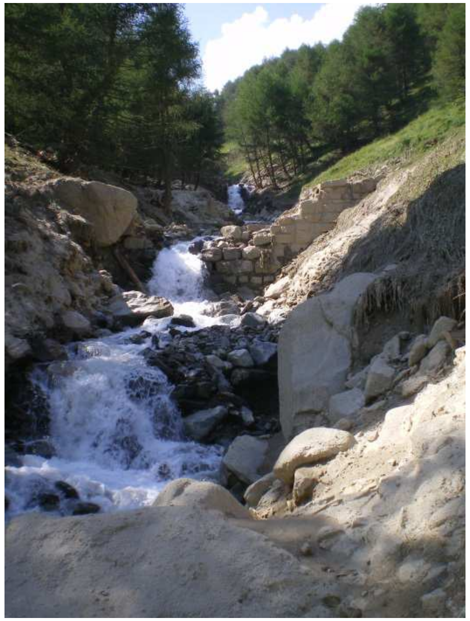
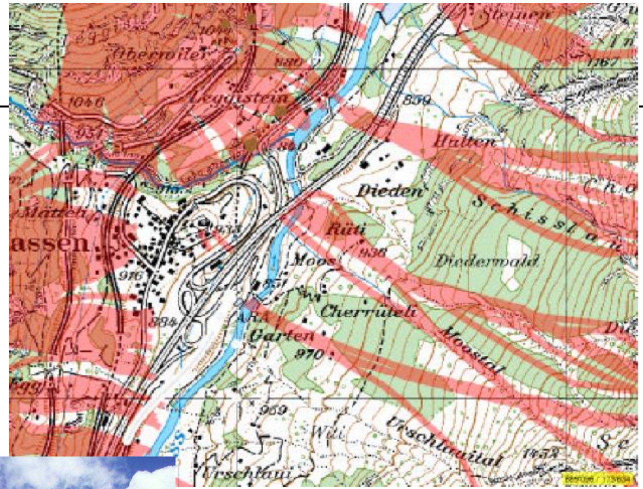
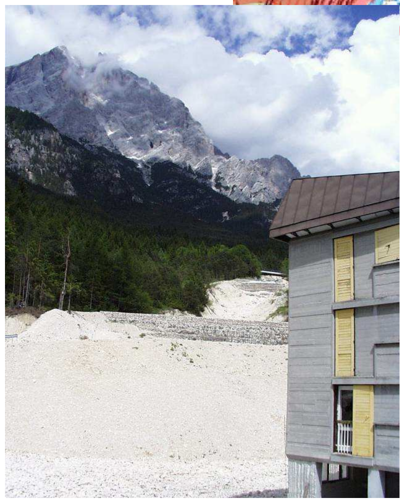
High residual risks
(in case of failure of underdesign)



Reduction of exposure

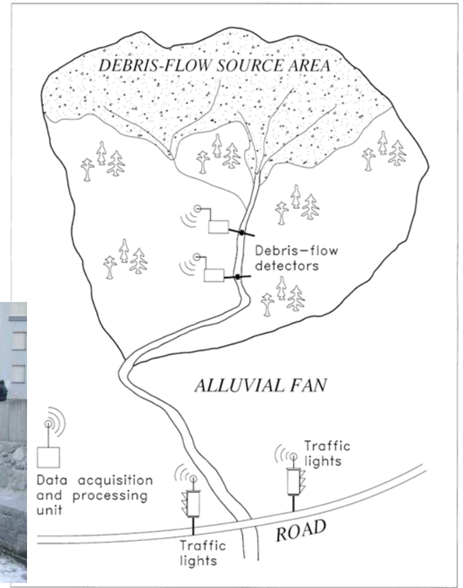


- Land use planning and insurance plans for future developments
  - ➡ Based on hazard maps



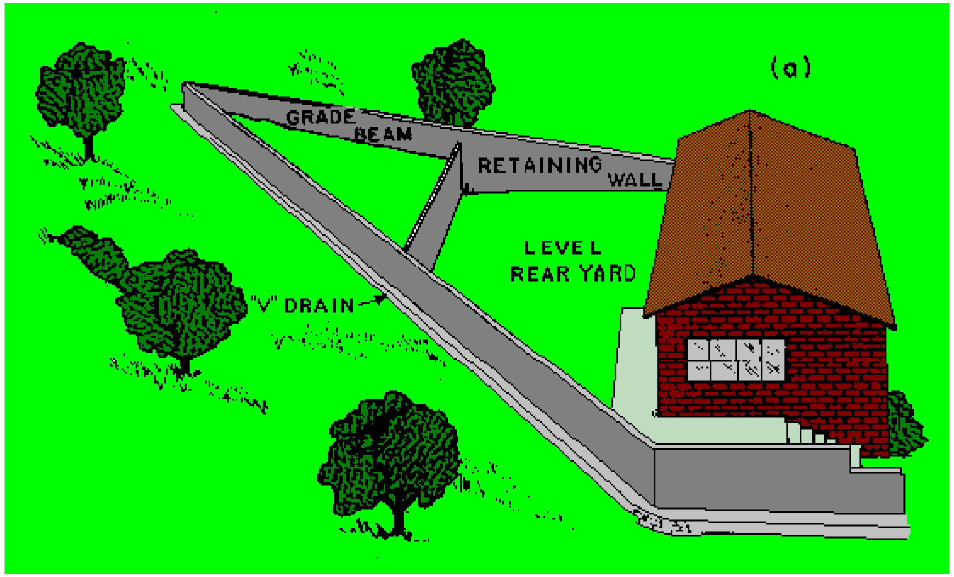
- Relocation of buildings/towns
  - ➡ Where possible/ socially accepted

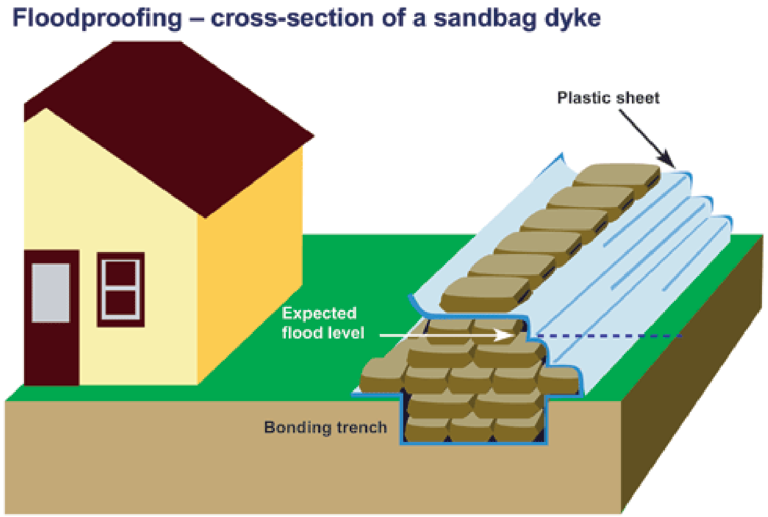
Arattano & Marchi (2008)

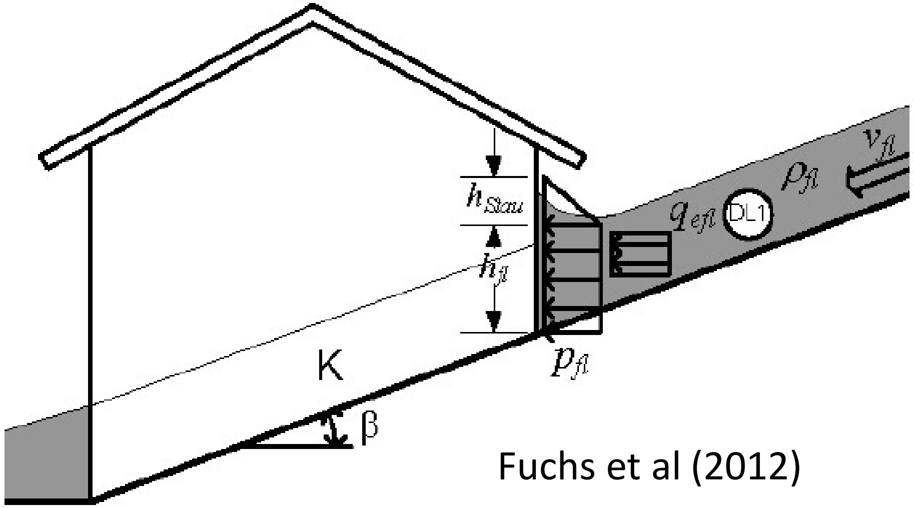


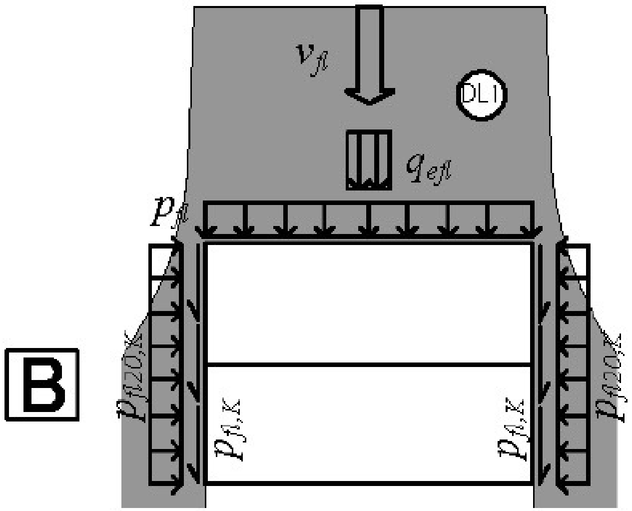
- Early-warning systems (for traffic/people)
  - ➡ Lead time is short in small mountain basins

Reduction of (physical) vulnerability









Fuchs et al (2012)

Reduction of (physical) vulnerability

Local structural protection measure	Type of measure	Effective for		Suitable for	
		Avalanche	Flood	Upgrade	New building
Foundation	Base plate foundation	(x)	x	-	x
Basement	Waterproofed concrete	-	x	-	x
	Enhancement (raising) of light shafts above flood level (flow depth), sealing of all wall penetrations	(x)	x	x	x
	Backflow flaps in sewage pipes	-	x	(x)	x
First (and second) floor	Reinforcement of the supporting structure (walls, ceilings, …)	x	x	(x)	x
Roof	Reinforcement of the roof, avoidance of eaves	x	-	(x)	x
Building openings	Decrease of the amount and area of windows and implementation of avalanche safe windows and/or heavy shutters	x	(x)	x	x

Fuchs et al (2012)