



Counter measures against extremely rapid mass movements

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Definitions - active measures



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- focus on the hazard
- may affect the initiation, transport or deposition of mass movements
- and can therefore change its magnitude and frequency characteristics
 - » disposition management: changing the probability of occurrence of a mass movement
 - » event management: manipulating the mass movement itself

Definitions - passive measures



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- focus on the potential damage
- principle of spatial separation of elements at risk from the hazardous area
- may reduce the potential loss by altering the spatial and temporal character of either the damage produced by mass movements or the associated vulnerability
- vulnerability of a disaster can be influenced either with administrative instruments (spatial planning, land use, hazard mapping) or through immediate disaster response

Definitions – permanent / temporary measures



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- Permanent measures
 - » comprehend durable technical and silvicultural measures as well as land use planning
 - » information of population is subsumed

- Temporary measures
 - » are adjusted to a certain point of time and the hazard potential of a location
 - » are executed spontaneously
 - » usually they complete or substitute the permanent measures with respect to an increased economic efficiency

Definitions – structural / non-structural measures



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- Structural measures
 - » include all physical measures used to mitigate natural hazards

- Non-structural measures
 - » are very site-specific and greatly depend on the organizational and legal boundary conditions in each country
 - » typically concentrate on identifying hazard-prone areas and limiting their use temporarily or permanently
 - » further forestal measures can be seen as non-structural measures

Definitions - mitigation measures



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			permanent protection effect	temporary protection effect
Active Mitigation Measures	Prevention	Disposition management	Catchment care Forest management activities Soil Bioengineering Technical measures	
		Event management	Technical measures	
	Reaction on the event			Immediate technical assistance
Passive Mitigation Measures	Prevention		Hazard maps Hazard adopted land-use Building Codes Action and Evacuation plans	Information Warning Alarm Evacuation
	Reaction on the event			Information Disaster management

Strategy of protection



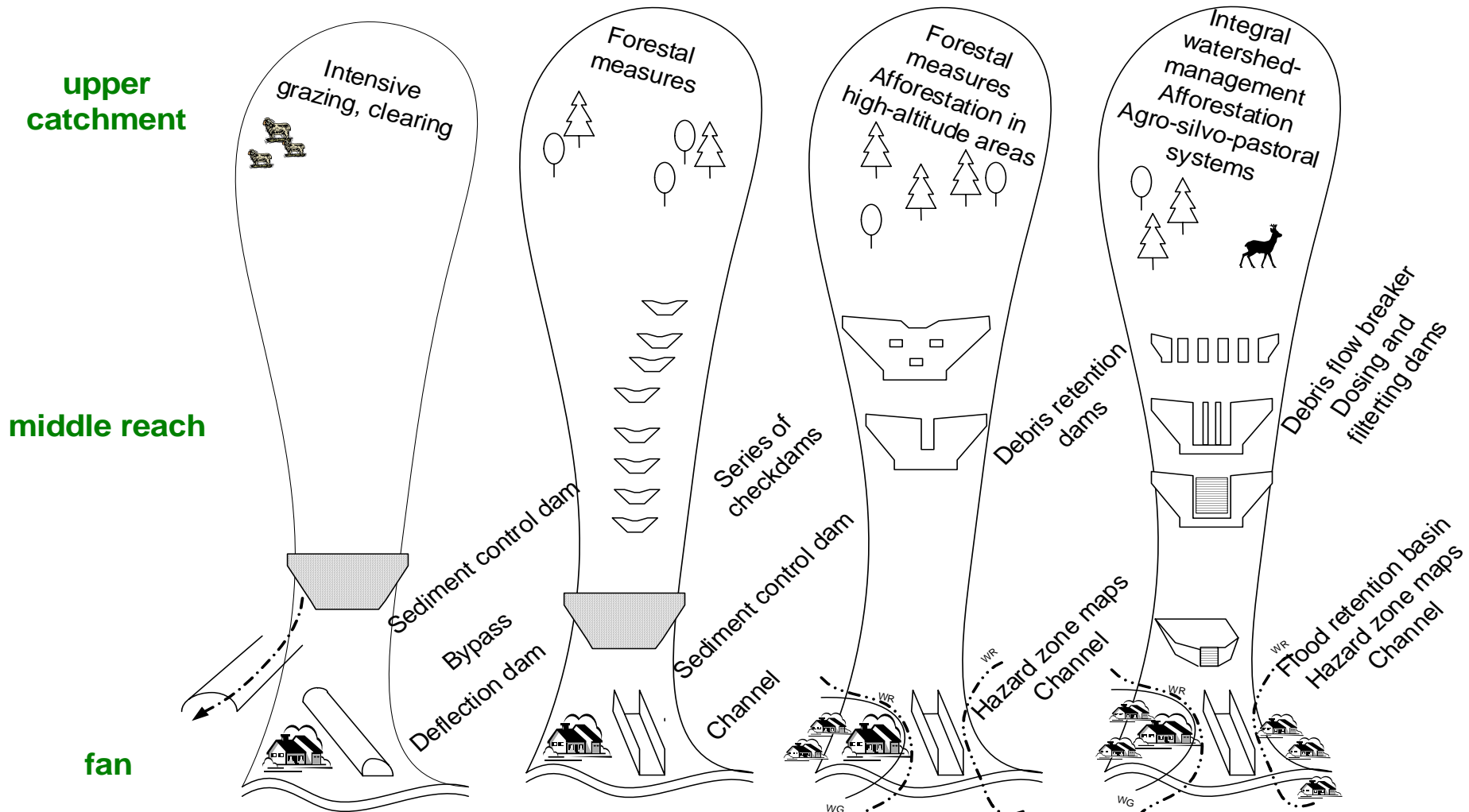
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- best combination of protection measures have to be identified
- special management tasks are assigned for unique elements of protection
- each task defines the performance of the single element with regard to the desired modification of the mass movement process
- ultimately, the sum of each element's functions must lead to the fulfilment of the overall protection objective

Strategy of protection – debris flows



The development from the beginning until today



sparse population **dense population**

Strategy of protection – debris flows



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■ Conduction

directing the debris flow on the shortest way through a potentially endangered area

■ Stabilisation

protection of the channel bed and the embankments against depth- and lateral erosion

■ Consolidation

raising the channel bed and reducing the stream gradient supports adjacent slopes of the channel

■ Bypassing

redirecting surface water around an erosion prone area to avoid excessive sediment recruitment along specific channel sections

■ Retention

leads to a more or less permanent deposition of sediments; sediments have to be excavated after an event

Strategy of protection – debris flows



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■ Dosing

temporary deposition of sediments; after the event the deposits should be released with the tail water; the intermediate storage of the accumulated material is designed to balance hazard mitigation and an ecological riverine environment

■ Filtering

allows particle segregation by grain size to allow only a given grain size to pass the structure

■ Energy dissipation

reduction of debris flow energy by slowing and depositing the surge front of the debris flow; downstream reaches of the stream channel and settlement areas are exposed to considerably lower dynamic impacts

■ Deflection

directs debris flows towards areas of low consequences; this requires the existence of areas with low economic value in which debris flows are allowed to deposit

Catalogue of countermeasures

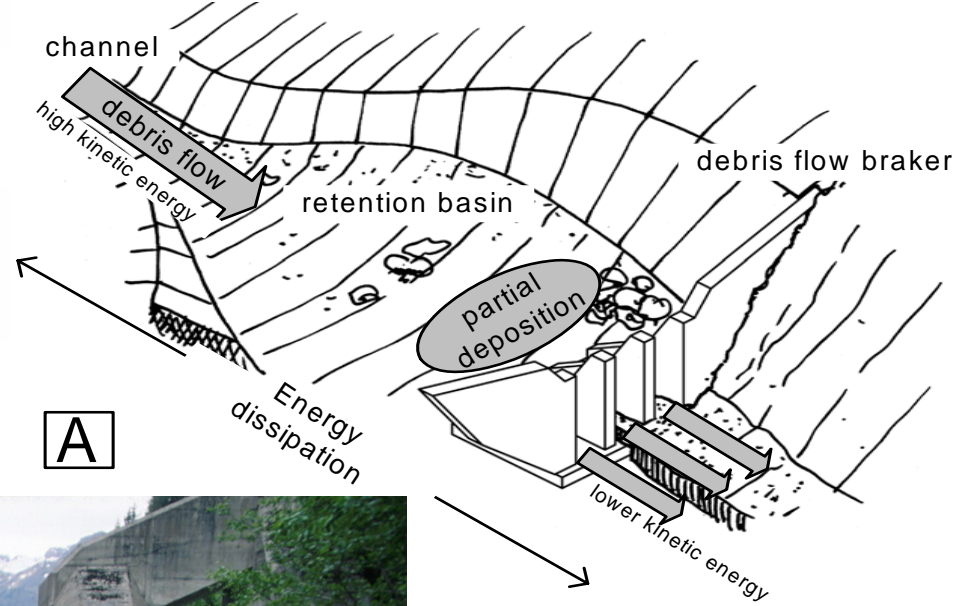
Debris flows



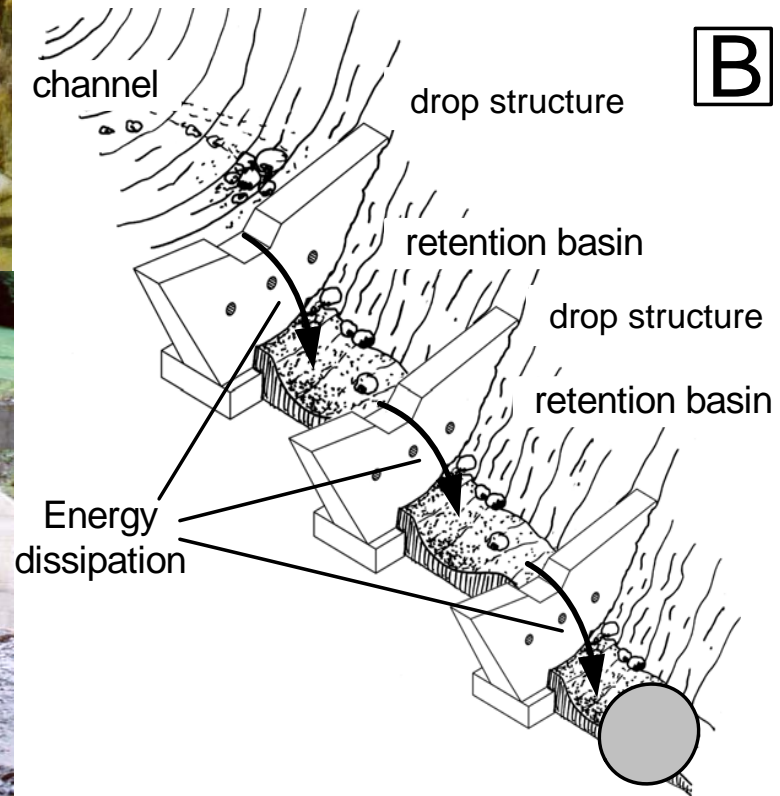
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Process	Counter measure	Type
Debris flow	Increase slope stability	Drainage
		Soil bio engineering
	Consolidation / Stabilization	Sill
		Ramp
		Closed check dam
	Transformation of process	Debris flow breaker
		Drop structure
	Organic debris filtration	Open check dam (rake)
	Permanent debris deposition	Open check dam
		Deposition basin
	Temporary debris deposition	Open check dam
	Protection / Deflection	Protection and deflection walls / dams
	Discharge control	Transport channel
Afforestation		

Debris flow breaker



Debris flow drop structure



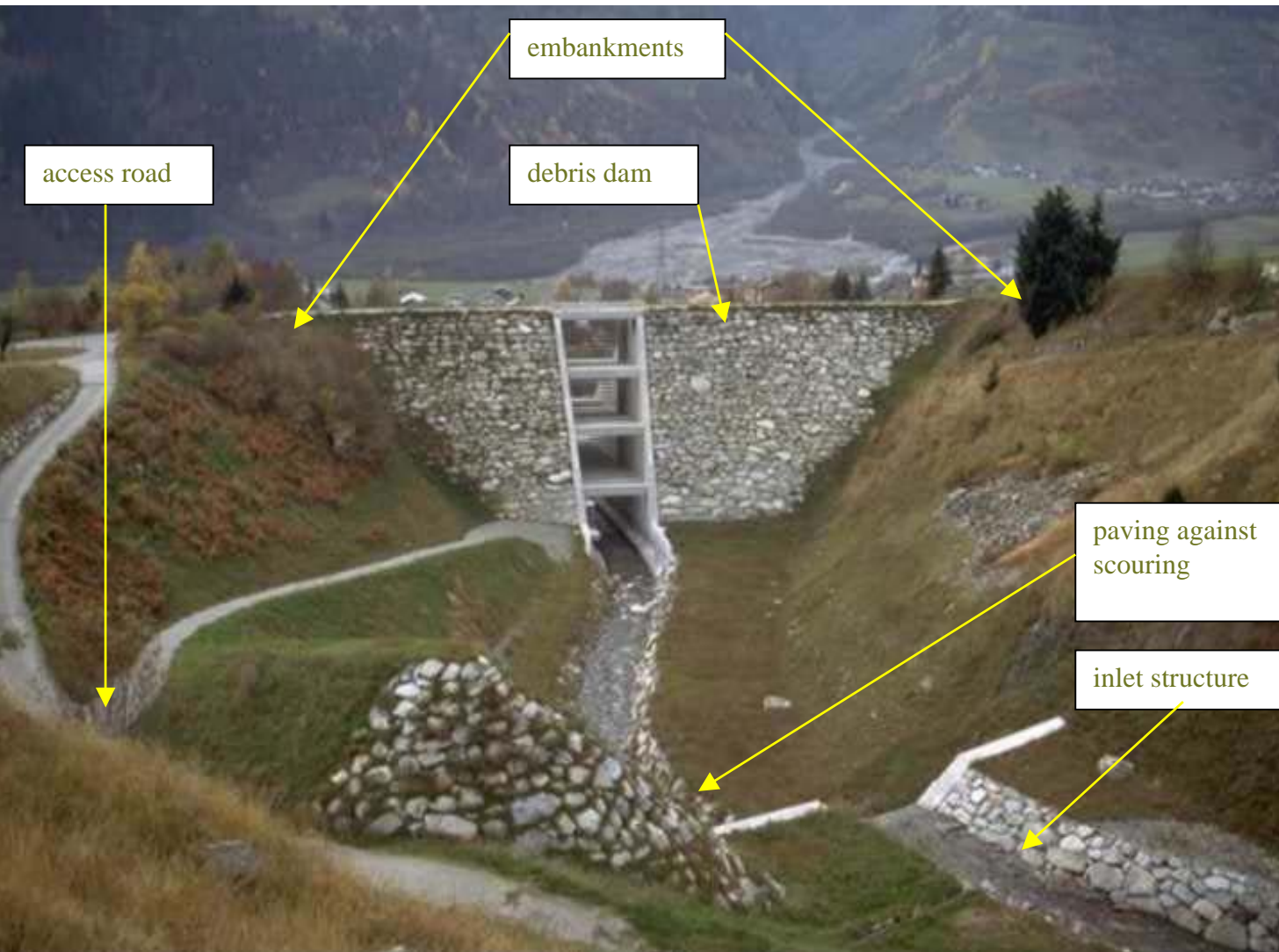
Organic debris filter



Debris flow retention basin



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access road

embankments

debris dam

paving against
scouring

inlet structure

Debris flow dosing and filtering



<p>Slot check dams</p>		
<p>Large slot check dam</p>	<p>Small slot check dam</p>	
<p>Slit check dams</p>		
<p>Slit check dam with vertical slits</p>	<p>Slit check dam with horizontal slits</p>	<p>Gap-crested slit check dam with vertical slits</p>
<p>Compound check dams</p>		
<p>Compound check dam with openings</p>	<p>Compound check dam with teeth</p>	
<p>Sectional check dams</p>		
<p>Sectional check dam with fins</p>	<p>Sectional check dam with piles</p>	<p>Sectional check dam with braces</p>
<p>Lattice check dams</p>		
<p>Rake check dam</p>	<p>Beam check dam</p>	<p>Frame check dam</p>
<p>Net barriers</p>		
<p>Net check dam</p>		

Strategy of protection – snow avalanches



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- Regulation of snow drift
 - » Structures influencing the wind flow, direction and speed and therefore the accumulation and deposition of snow masses
- Stabilising snow masses (release area)
 - » supporting structures to retain, sustain or support the snow cover in place and to prevent it from sliding
- Influence of already triggered snow masses
 - » Structures deflecting or catching the snow masses
- Artificial release of snow avalanches
 - » Simple explosives up to high sophisticated blasting devices

Catalogue of countermeasures snow avalanches



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Process	Counter measure	Type
Snow avalanches	Snow drift regulation	Snow fence
		Jet roof
		Wind baffle
	Stabilizing constructions	Snow bridge / rake
		Snow net
		Tripod
	Braking constructions	Avalanche breaker
	Deflecting and catching constructions	Deflecting and catching dam
		Gallery
		Tunnel
	Artificial release	Aerial cableway
		Preplaced explosives
		Gas exploders
		Guns
Afforestation		

Snow avalanches

Snow fence – jet roof – wind baffle



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Counter m

Examples – snow avalanches

Snow net – snow bridge - tripod



Examples – snow avalanches

Avalanche breaker – avalanche deflection



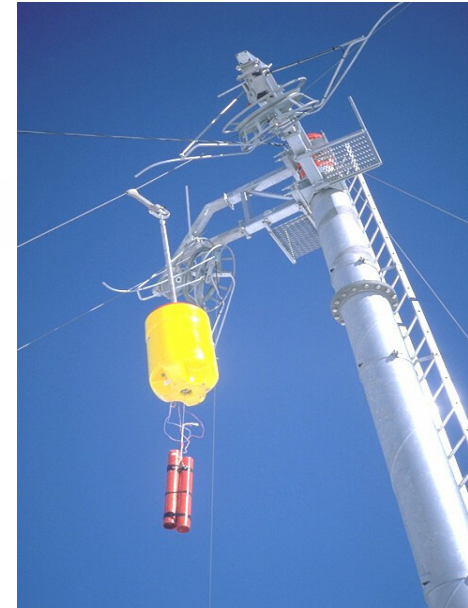
Examples – snow avalanches

Gallery – tunnel



Examples – snow avalanches

Gas exploders - cable ways – av. guard –
av. tower - afforestation



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Strategy of protection – rock avalanches



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- Structural measures used for smaller rock falls (anchors, rock bolts, nets, concrete ribs) are unsuitable for rock avalanches (large volume, great forces)
- Due to low frequency only little knowledge about triggering mechanisms
- **Monitoring systems** to obtain better process understanding
- **Temporary passive mitigation measures**
 - » Effective warning systems for rock slope movements
 - » Emergency planning including evacuation and road closure to reduce the consequences of rock avalanches

Catalogue of countermeasures rock avalanches



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Process	Counter measure	Type
Rock avalanches	Removing unstable rock mass by blasting	
	Drainage	
	Diversion of surface water	
	Underground water drainage	

Rock avalanches monitoring



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Extensometer



GPS

Tiltmeter

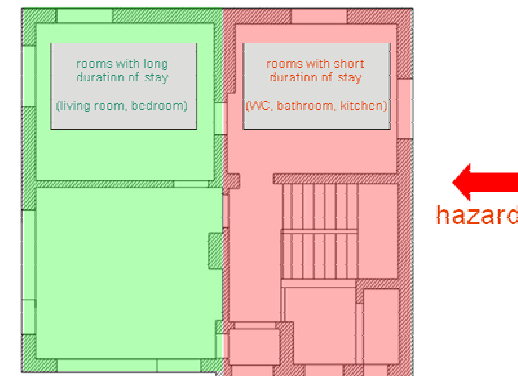


Administrative and organizational methods



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- Land use planning based on hazard maps
- Information and education
- Local structural protection measures
- Preparedness and emergency plans
 - » Evaluation of danger level
 - » Identification of exposed areas
 - » Detailed activity plan
 - » Organizational plan



Conclusion



- Different kind of infrastructures may have different demands concerning safety levels (social demand for protection, risk acceptance, residual risk)
- Strategy of protection:
 - » Use of non-structural measures
 - Short-term perspective: preparedness plans, hazard forecasting, temporal evacuation
 - Long term perspective: land use planning and legislation
 - » Use of structural measures
 - » Relocation of the endangered people and infrastructure
- Best solution both for the people exposed to the hazard, and for the local and national society. It is to be kept in mind that the interest of these three groups is not always congruent (cost-benefit-analysis).



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Thank you!

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