EUROPEAN COMMISSION
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European Soil Bureau Network

BGR

Workshop
Common Criteria for Risk Area Identification in the Soil Framework Directive
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Common Criteria

to delineate risk areas for

Landslides

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1. Rationale on Landslides

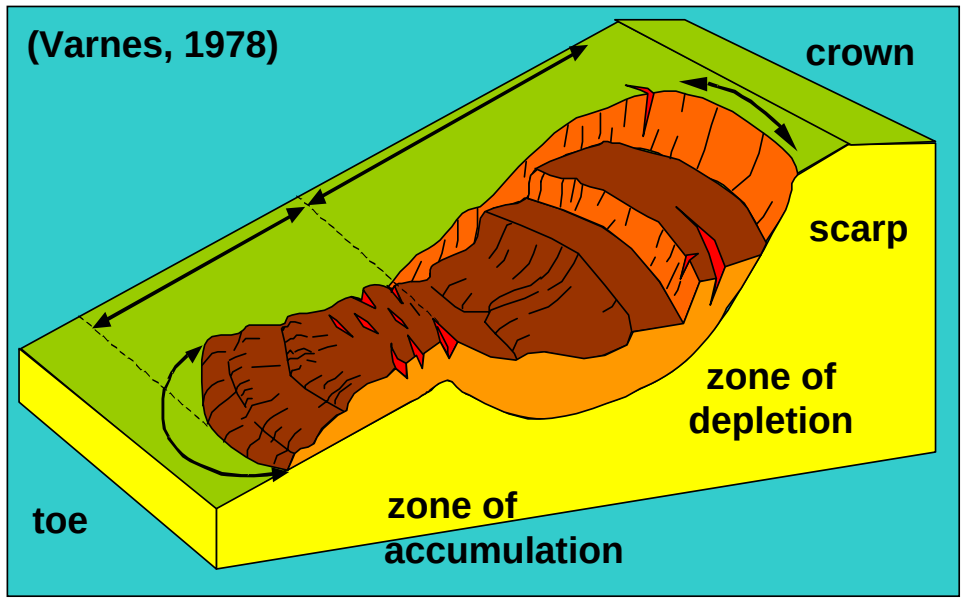
Simple definition of the threat

LANDSLIDE: movement of a mass of rock, debris, or earth down a slope. (Cruden, 1991).

Landslides are a type of "mass wasting" which denotes any down slope movement of soil and rock under the direct influence of gravity.

Internal factors

External factors



Controlling factors

Triggering factors

- **Several orders of velocity**
- **Several orders of magnitude**

1. Rationale on Landslides

Classification of slope movements

TYPE OF MOVEMENT			TYPE OF MATERIAL		
			BEDROCK	ENGINEERING SOILS	
				Predominantly coarse material	Predominantly fine material
FALLS			Rock fall	Debris fall	Earth fall
TOPPLES			Rock topple	Debris topple	Earth topple
SLIDES	**Rotational**	**Few Units**	Rock slump	Debris slump	Earth slump
	Translational	**Many Units**	Rock slide	Debris slide	Earth slide
LATERAL SPREADS			Rock spread	Debris spread	Earth spread
FLOWS			Rock flow (deep creep)	Debris flow (soil creep)	Earth flow (soil creep)

(Varnes, 1978)

2. Controlling/triggering factors

- **Ground material conditions** (*plastic weak/sensitive/collapsible material, weathered/sheared/jointed material, adversely oriented mass/structural discontinuities, contrast in permeability*)
- **Geomorphologic processes** (*tectonic/volcanic uplift, glacial rebound, fluvial erosion of the slope toe, erosion of the lateral margins, deposition loading of the slope or its crest, vegetation removal by erosion/forest fire/drought)*
- **Physical processes** (*intense/prolonged rainfall, rapid snow melt, rapid drawdown following floods, earthquake, volcanic eruption, thawing of permafrost, freeze and thaw weathering, shrink and swell weathering of expansive soils)*
- **Man-made processes** (*excavation/loading of the slope or its crest, irrigation, water leakage from services, deforestation, mining and quarrying, artificial vibration)*

2. Controlling/triggering factors

Snowmelt induced landslides

Valderchia, Umbria, central Italy, 6 January 1997
Photograph: © CNR-IRPI, Perugia

2. Controlling/triggering factors

Rainfall triggered soil slide – debris flows

Piedmont, northern Italy, 3-5 November 1994
Photographs: Casale and Margottini, 1996

2. Controlling/triggering factors

Earthquake triggered landslide

Neelum River, Pakistan, 2006
Photograph: Lt. Wiley Thompson, 2006 (www.geo.oregonstate.egu)

3. Terms and definitions

- **Landslide hazard** is **"the probability of occurrence, within a specified period of time and within a given area, of a potentially damaging failure"** (*Varnes and IAEG Commission on Mass-Movements, 1985*).
- An extended definition includes **"the magnitude of the event"** (*Guzzetti et al., 1999*).
- The definition incorporates the concepts of **location**, **time**, and **magnitude** of landslide hazard

$$H_L = P(A_L) \times P(N_L) \times S$$

P (A_L)*:* Probability of landslide size, a proxy for **magnitude**

P (N_L)*:* Probability of **temporal** occurrence of a landslide

S: **Landslide susceptibility** probability / possibility of **spatial** occurrence

3. Terms and definitions

- **Specific landslide risk** is **"the expected degree of loss due to a landslide"** *(Varnes and IAEG, 1984)*

$$R_s = H_L \times V_L$$

- **To determine risk, one needs to know:**
  - **landslide hazard, H_L**
  - **landslide vulnerability, V_L**

- **Landslide vulnerability** is **"the degree of loss to an element at risk resulting from the occurrence of a landslide of given magnitude"** *(Varnes and IAEG, 1984).*

- Since landslide risk will be very difficult to evaluate at an European scale, the landslide threat might be best accomplished with **landslide susceptibility assessments** (i.e., spatial component of H_L)

4. Landslide susceptibility assessments

Heuristic susceptibility zoning without landslide data

Example: Qualitative landslide susceptibility map for Germany

Bedrock/soil associations classified to landslide susceptibility (A. Richter, BGR)

- none
- very low
- low
- moderate
- high
- very high
- no data

Classified slope (DGM 50 data)

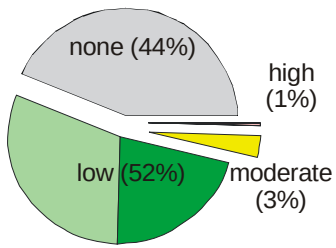
- < 5°
- 5 - 10°
- 10 - 20°
- 20 - 30°
- 30 - 40°
- > 40°
- no data

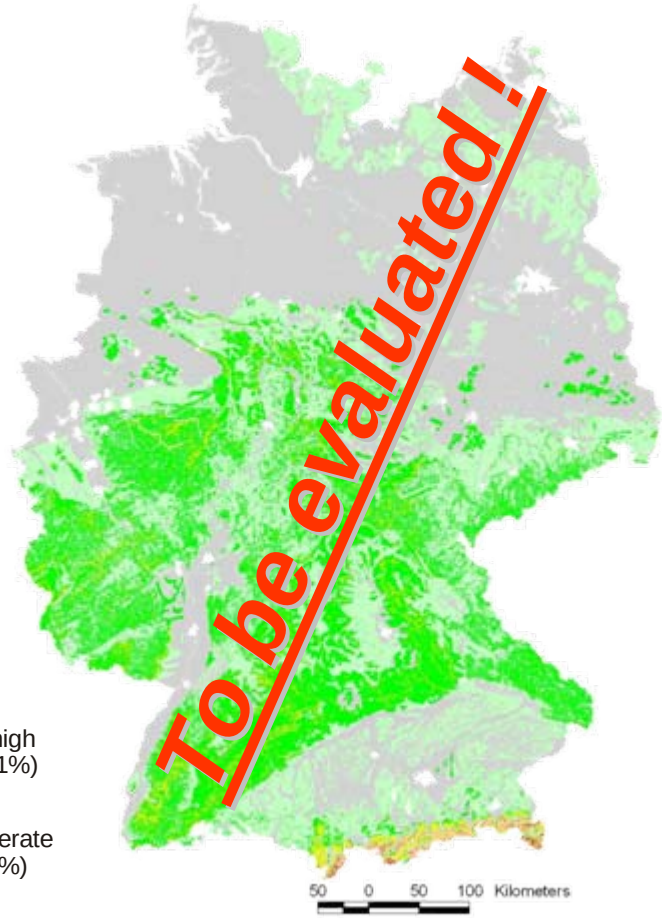
Weighted Matrix Overlay

Landslide susceptibility

1 None
2
3 Low
4 Moderate
5
6 High
No data

Area % of susceptibility

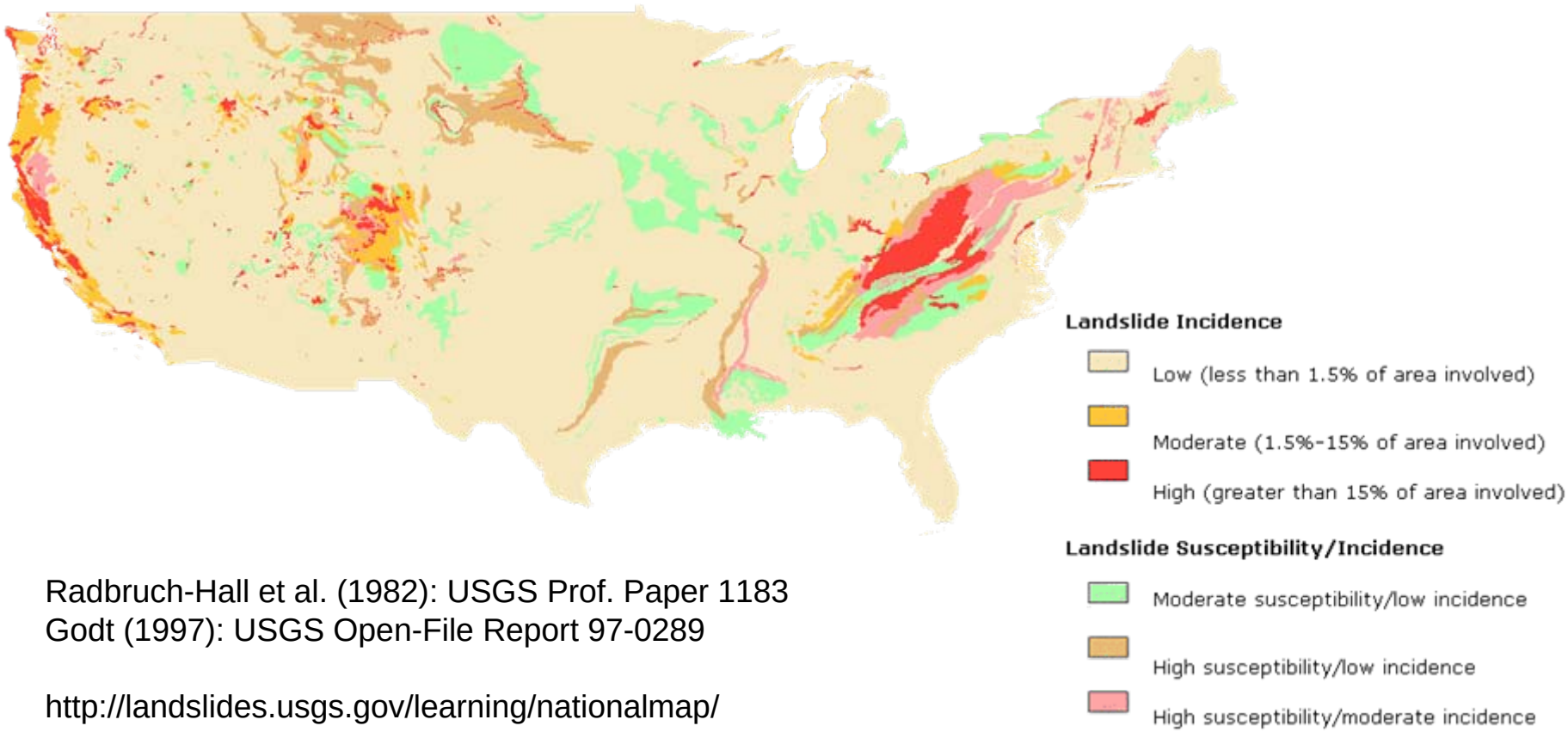




4. Landslide susceptibility assessments

Susceptibility zoning with landslide inventories

Example: Landslide overview map of the conterminous United States



Radbruch-Hall et al. (1982): USGS Prof. Paper 1183
Godt (1997): USGS Open-File Report 97-0289

http://landslides.usgs.gov/learning/nationalmap/

4. Landslide susceptibility assessments

Statistical landslide susceptibility modeling

Example: Probabilistic landslide susceptibility model for Italy

Soil map

Elevation model

Geological map

Thematic data: Independent variables

Landslide map

21.159 historical landslides

http://sici.irpi.cnr.it

Landslide events: Dependent variable

Discriminant Analysis

PROBABILITY
[0.00 - 0.20]
(0.20 - 0.45]
(0.45 - 0.55]
(0.55 - 0.80]
(0.80 - 1.00]

5. Common criteria

Common criteria	Data source/type of information	Data Quality /Resolution	
		Tier 1	Tier 2
occurrence/density of existing landslides	statistics	NUTS III	larger-scale regional/local assessments
Bedrock	nature of material + presence of fissures and pores	Map of Geology 1:1,000,000	higher resolution maps
soil properties	texture, structure, permeability	*not required for in Tier 1*	classification/grouping according to?
Slope	classes: 0-10°; 10°-30°; >30°	250m	*same or higher*
land cover/land use	infrastructure; cultivation density/pressure, mining	*Non relevant for Tier 1*	100m
Climate	likelihood of heavy rainfall events	daily events (e.g. < 10, 10-70, >70 mm/day)	*same or higher*
seismic risk		threshold?	threshold?

Common criteria formulated by SIWG

5. Common criteria

Existent data for delineation of landslide-susceptible regions

- Digital Terrain Model (SRTM 90)
- Topographic attributes derived from DTM (e.g.: slope, stream network, flow accumulation, …)
- Geological map (1:1,5 Mio Europe, analogue)
- Soil/Parent material in the European Soil Geographical Database 1:1 Mio (digital)
- Climate (problem: MARS 50Km)
- Seismicity (Earthquake catalogue)

- Representative available landslide data for establishment / evaluation / adjustment of susceptibility criteria / classes

5. Common criteria

Additionally needed data for landslide hazard zonation

- Landslide density information (?NUTS 3)
- (Multi-temporal) landslide inventory maps
- Historical landslide catalogues
- Bedrock/soil properties (shear strength, structure, permeability, …)
- Land cover / land use
- Daily intensity/duration rainfall series to define rainfall thresholds
- Ground acceleration maps to define seismic thresholds

Additionally needed data for landslide risk evaluations

- Maps of elements at risk
- Data on population density

6. Conclusions

Current trend

- Climate change locally increases the intensity of rainfall, raising the frequency of fast moving, shallow landslides
- Intensification of land-use management amplifies the hazard
- Population growth, expansion of settlements and infrastructure over potentially hazardous areas have increased the impact of landslides
- Soils are vulnerable to all kinds of landslides

6. Conclusions

- Landslides are local phenomena controlled/triggered by a large variety of internal/external factors
- Landslide risk is difficult to evaluate, since it requires knowledge about the temporal probability of the hazard, its damaging potential, and data on objects at risk
- A wide array of methods to evaluate landslide susceptibility at different scales is available and used for nation-wide assessments
- Without landslide inventory data, only speculative and conceptual assessments can be performed (but cannot be evaluated)

7. Questions

- Can we define landslide risk from a soil perspective?
- Is it possible to agree on a landslide inventory system at an European level?
- As part of such an approach: can European-level landslide protocol recommendations be established?
- Can we define what landslide susceptibility models are most appropriate at which scale and in which regions?
- Can we establish European LS assessment strategies? If so, for which scales and with what kind of data?