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Overview of input data for Quantitative Risk Analysis from the consequences of geohazard

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Overview of input data sources and their relevance for Quantitative Risk Analysis (QRA)

Table 1. Overview of input data sources and their relevance for quantitative risk analysis for different landslide mechanisms (**F** = fall, **SL** = shallow landslides and debris flows, **LSL** = large slow landslides)

Basic source	Data group	Examples	M	Scale N	Scale R	Scale L	Scale LS	Relevance F	Relevance SL	Relevance LSL
Laboratory analyzes	Soil properties	Grain size distribution, saturated and unsaturated shear strength of soil, soil water retention curves, hydraulic conductivity of saturated soil, clay minerals, sensitivity, viscosity, density.	Ps	x	x	o	•	L	C	V
	Rock properties	Unlimited compressive strength, shear strength, mineralogy.	Ps	x	x	o	•	C	L	C
	Vegetation properties	Tensile strength of roots, strength of pulling of roots, evapotranspiration.	Ps	x	x	o	•	L	V	M
	Age assessment	Radiocarbon C-14 test, pollen analysis.	Pl	o	o	o	•	L	L	V
Terrain measurements	Landslide age	Dendrochronology, lichen method for estimating landslide age, tephrochronology, archaeolog. artifacts.	Pl	o	o	o	•	M	M	V
	Depth of soil	Wells, trenches, pits, material outcrops, material sampling drills.	Ps	x	x	o	•	L	C	M
	Geophysics	Seismic wave refraction, microseismic observation, electromagnetic method, magnetic method, ground-penetration radar, geophysical drilling methods.	Ps	x	x	o	•	L	M	V
	Soil characteristics	Standard penetration tests, field drilling.	Ps	x	x	o	•	L	C	M
	Rock characteristics	Lithology, discontinuities (types, spacing, orientation, openings, fillings), rock mass ranking.	Ps	x	x	o	•	C	L	V
	Hydrological characteristics	Infiltration capacity, water face fluctuation, soil absorption, pore pressure.	Ps	x	x	o	•	V	C	C
	Characteristic of vegetation	Root depth, root density, vegetation species, crop factor, ratio of rock cover material.	Ps	x	x	o	•	M	V	L

*Note: Importance is marked as **C** (crucial), **V** (very important), **M** (moderately important) and **L** (less important).*
The potential for this information is collected at different levels and is presented as: • = possible, o = difficult possible, x = not possible.
*The scales are: **N** (national level), **R** (regional level), **L** (local level) and **LS** (local specific level).*
***M** denotes the method used for spatial data collection where: **Pl** = point (local) data related to individual specifics, **Ps** = sample of points that characterize spatial units, **Pn** = points in the network to be interpolated, **Sc** = data based on surface characteristics, **Cs** = complete surface coverage, **L** = line data.*

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Observation networks	Landslide shifts	Electronic distance measuring devices, GPS systems, theodolite, terrestrial laser scanner, interferometry.	Pl	x	x	o	•	V	V	V
	Groundwater	Piezometers, strain gauges, water flow measuring stations.	Pn	x	x	o	•	V	C	C
	Meteorological data	Precipitation, temperature, humidity, wind speed.	Pn	•	•	•	•	V	V	V
	Seismic data	Stations for measuring seismic activity, stations for strong displacement, microseismic studies.	Pn	•	•	•	•	V	V	V
Area mapping	Landslides	Type, relative age, speed of movement, state of activity, initiations, transport of materials, zones of deviation, area, depth, volume, consequences.	Sc	o	•	•	•	C	C	C
	Geomorphology	Characterization of landslide shapes, processes, surface material.	Cs	o	o	•	•	L	V	V
	Soil types	Textures, soil classification, boundary area mapping, conversion to engineering soil types.	Cs	o	o	•	•	L	C	V
	Lithology	Lithological mapping, meteorological zones, border area mapping, formations.	Cs	o	o	•	•	C	V	V
	Structural geology	Depth measurements of cover plane and discontinuity, stratigraphic reconstructions, mapping curve, structural reconstruction.	Cs	o	o	•	•	V	L	V
	Vegetation	Vegetation type, density, leaf growth area index.	Cs	o	o	•	•	L	V	M
	Land use	Types of land use, characterization of vegetation by land use.	Cs	o	o	•	•	V	V	V
	Elements of risk	Typology of construction, structural system, foundation systems, classification of roads and pipelines.	Sc L	o	o	•	•	V	V	V

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Archival studies and data from the past	Landslides in the past	Historical data on location, date of origin, trigger mechanisms, size, volume, range length.	Sc Pl	o	o	•	•	V	V	C
	Damage data	Historical data on economic losses and affected population with dates, location and characterization.	Pl	o	o	o	o	V	V	V
	Meteorolog-ical data	Precipitation (continuous or daily), temperature, wind speed, humidity.	Pl	•	•	•	•	V	V	V
	Land use change	Historical maps of land/cover use for different periods.	Pn	•	•	•	•	M	V	V
	Elements of risk	Historical maps of buildings, transport infrastructure, economic activities and population characteristics.	Cs	•	•	•	•	V	V	V
	Digital height values	Topographic maps with isohypses, digital relief models.	Sc L	•	•	•	•	V	V	V
	Thematic maps	Geological, geomorphological, channel networks and other existing thematic maps.	Cs	•	•	•	•	V	V	V
Remote sensing	Aerial photography and high resolution satellite imagery	Interpretation of images for mapping and characterization of landslide locations, geomorphology, land/cover use, mapping of risk elements.	Sc Cs	o	•	•	•	C	C	C
	Multispectral images	Image classification methods for landslide mapping, land/cover use, normalized vegetation difference index, leaf growth index for a specific area.	Sc Cs	•	•	•	•	M	V	M
	Digital elevation data	Aerial stereophotogrammetry, space stereophotogrammetry, LIDAR, InSAR.	Cs	•	•	•	•	C	C	C

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Conclusions

Three basic components for the risk of the consequences of geohazard: hazard, exposure of at-risk elements and their vulnerability. The procedure for determining the risk analysis of geohazard consequences:

(i) geohazard analysis - includes analysis of intensity, probability of rock mass slip and its potential reach,

(ii) identification of risk elements - including number of occurrence, value and degree of exposure,

(iii) vulnerability analysis and

(iv) risk assessment.

The susceptibility to the occurrence of possible geohazards can be determined on the basis of geomorphological mapping, empirical or semi-empirical evaluation systems, as well as deterministic and statistical methods.

Methods for determining the propagation of debris flow and mudflow - divided into two main categories, empirical and physical methods. **Empirical methods** - allow a rapid assessment of the propagation of debris flow and mudflow (the relationship of topographic slope factors and the length of the flow range). **Physically based methods** - complex methods that use numerical simulations of motion and propagation (expressed by the kinetic energy of hydrodynamic impact).

Geohazard zoning at national, regional and local scales is carried out using simple methods based on heuristic or empirical procedures, unfortunately neglecting the time component.

When assessing **hazard on a large scale**, it is proposed to adopt a quantitative method over a qualitative one, which separates the assessment of hazard and risk.

Questions or comments?

Thanks for your attention and patience!

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