Landslide Hazard and Risk Methodology:

Review of Concepts

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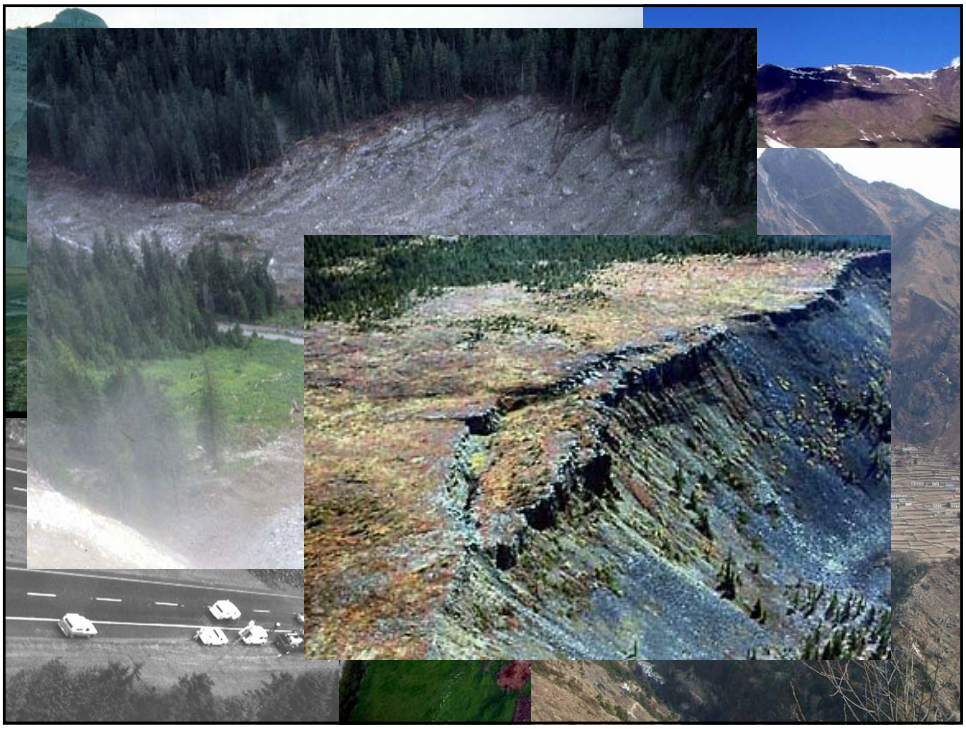

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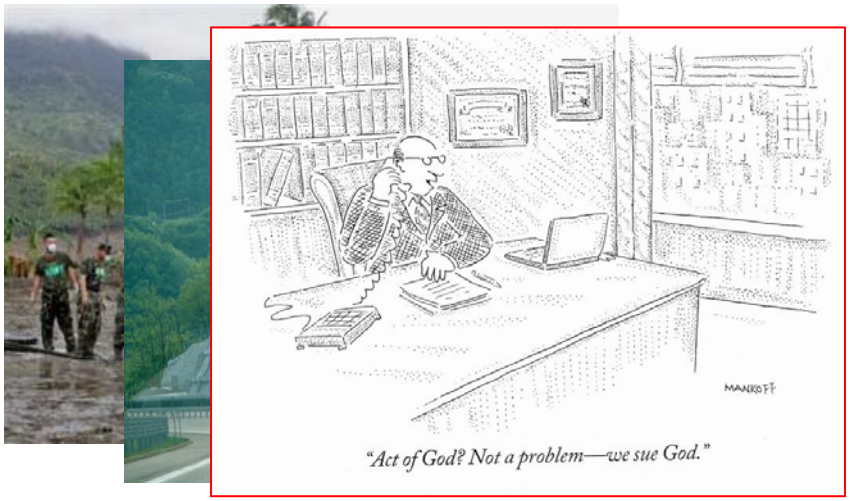
2) prevent excessive expenditure
3) protect ourselves



Hazard and Risk Terminology:

Hazard: *Arabic "a die".*

UN definition: "the probability of occurrence of a damaging phenomenon" (Varnes, 1984)

Preferred definitions: "Possibility of a damaging phenomenon occurring" or "Something that can potentially cause loss"

Common usage: natural hazard, geological hazard, landslide hazard and similar. A general term with a very wide meaning.

Hazard Characteristics:

Hazard **is characterized by several factors:**

- **Hazard type**
- **Hazard magnitude**
- **Hazard probability**
- **Hazard intensity**
- **And combinations of these**

Hazard is not probability! What probability? Of occurrence? Of impact? Of damage?…….

Risk:
Probability of loss x value of loss

Risk to life:

PDI: *Probability of death of an individual*

PDG: *Probability of death of a group of individuals*

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Risk is only present if elements at risk are present.
Hazard always exists, regardless of the elements at risk

Hazard and Risk Assessment (Hungr, 1997)

Stage 1 – Hazard Assessment

1. estimation of magnitudes
2. recognition of hazard
3. estimation of corresponding probabilities of occurrence
4. estimation of hazard intensity distribution
5. estimation of probabilities related to intensity
6. hazard assessment report

Stage 2 – Risk Assessment

7. determination of elements at risk
8. estimation of vulnerabilities
9. calculation of specific risks
10. calculation of total risk
11. assessment of risk acceptability
12. mitigation of risk (if necessary)

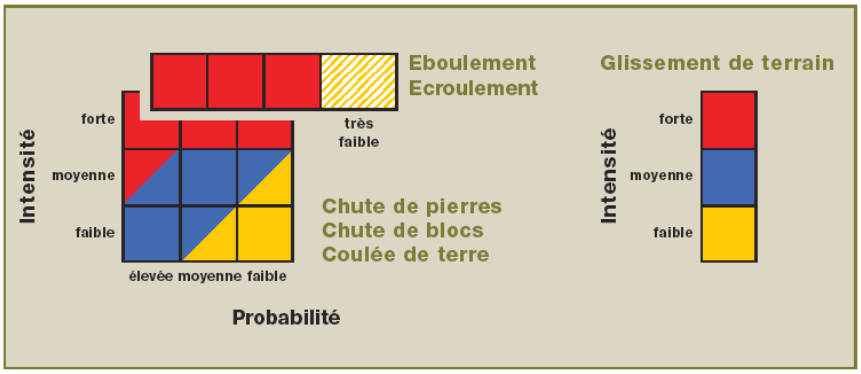
Hazard and Risk Assessment: Advantages of separation:

1) Geoscientist retains unambiguous responsibility for hazard assessment, others must contribute to risk assessment.

2) Option to use:
hazard acceptability (Switzerland, Canada), or
risk acceptability (Hong Kong, Australia)

3) Elements at risk may change or move: same hazard map can be used.

Swiss guidelines (Lateltin, 1997)



Consequence:

Difficult to use for landslides. Spans division between hazard and risk.

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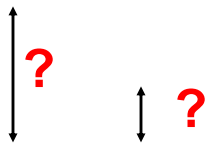
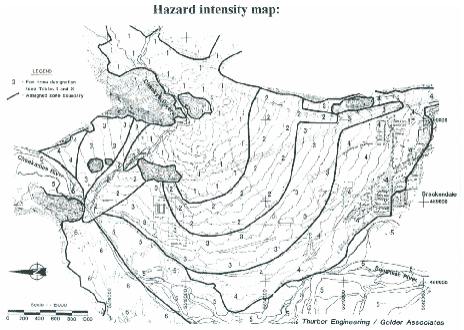


"Risk=hazard (probability) x consequence: What probability? Ambiguous and unnecessary equation.

Intensity (I): ***A spatial function describing the distribution of the effects of the hazard event. E.g. peak acceleration or velocity of earthquake shaking, or a qualitative description using the Mercalli scale. For landslides: movement velocity, depth of deposits, strain etc.***



Cheekye Fan

Elements at Risk (E): ***people, animals, land, resources, environmental values, buildings.***

Vulnerability (V): ***the degree of damage caused by the hazard event to the elements at risk. Varies from 0 to 1 (total loss) - a function of intensity!***

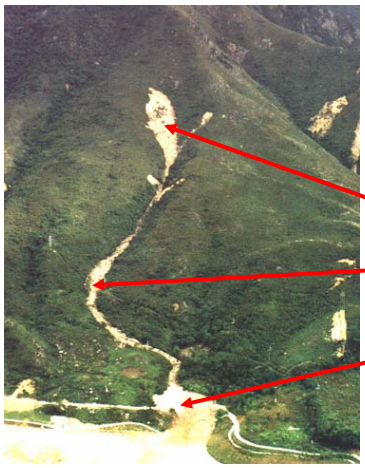
Train derailment due to a debris flow

~$10 million

Probability: *not a simple parameter, but several:*

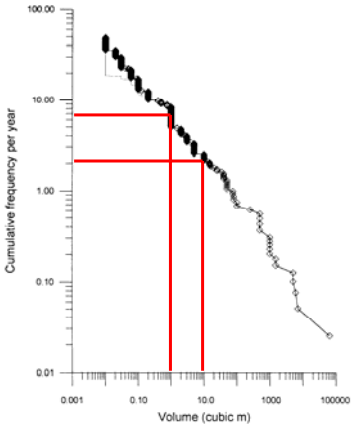
1) ***probability of occurrence of a landslide***
   (a specific one, or one of a given type, magnitude)
2) ***probability of extremely rapid failure***
   (there may be no significant runout)
3) ***spatial probability of impact***
   (will the slide go far enough and hit the target?)
4) ***probability of intensity***
   (what is the probability of certain intensity level?)
4) ***temporal probability***
   (will the target be there? - part of risk assessment)

Impact probability : *A product of the probability of landslide occurrence and the conditional probability of impact, given occurrence. - determined by a runout study.*



$P_i = P : P_i$

Cumulative Frequency –Magnitude (CFM) curve



(Hungr et al., 1999)

CFM curve for rock fall on BC Hwy 99 between Vancouver and Squamish, compiled from observation records.

Example: annual frequency of of rock falls in the magnitude range 1 to 10 m^3 equals 7-2=5

Difficulties with FM relationships:

1) **Scarcity and poor quality of data**
2) **Censoring**
3) **Non-homogeneity (clustering) of data**
4) **Non-stationarity: changed conditions or depletion**
5) **Non-randomness: magnitude may depend on size of slope and other factors**

Relationship between frequency and probability

Relationship between frequency and probability in a given time period of r years

$$P = 1 - (1 - f)^r$$

If the period r is less than 20% of the return period T=1/f, then we can say approximately (up to 10% error):

$$P \sim= fr = r / T$$

Subjective probability assignment

Probability Class		Annual Probability Range
Very High	VH	>1:20
High	H	1:100 – 1:20
Medium	M	1:500 – 1:100
Low	L	1:2500 – 1:500
Very Low	VL	< 1:2500

(Hungr, 1997)

Failure: ***The most important movement episode in the past or future history of the landslide and one that leads to complete detachment, i.e. the formation of a continuous rupture surface.***

Beatton River, NE B.C.

Susceptibility

Landslide susceptibility = expected landslide density (in cases/km^2/year, or m^2/km^2/year, or H,M,L)

FRAMEWORK: Grid of pixels / Polygons
SCALE: Overview (<1:20 000), Medium, Large (>1:10 000)
METHODS (Soeters and VanWesten, 1996):

1. Landslide Inventory
2. Subjective-geomorphic
3. Parameter rating
4. Bi-variate statistical
5. Multi-variate statistical
6. Deterministic