F-N Curves, Social Aspects and Risk Acceptability

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Basic Definitions

Acceptable risk: A risk which everyone impacted is prepared to accept. Action to further reduce such risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort.

Tolerable risk: A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.

ALARP (As Low As Reasonably Practicable) principle: Principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly in disproportion (depending on the level of risk) to the improvement gained.

F-N curves: Curves relating the probability per year of causing N or more fatalities (F) to N. This is the complementary cumulative distribution function. Such curves may be used to express societal risk criteria and to describe the safety levels of particular facilities.

Societal risk: The risk of widespread or large scale detriment from the realisation of a defined risk, the implication being that the consequence would be on such a scale as to provoke a socio/political response.

Acceptable Risk in Risk Assessment

- What are the probable dangers/problems? [Danger Identification]
- What would be the magnitude of dangers/problems? [Hazard Assessment]
- What are the possible consequences and/or elements at risk? [Consequence/Elements at Risk Identification]
- What might be the degree of damage in elements at risk? [Vulnerability Assessment]
- What is the probability of damage? [Risk Quantification/Estimation]
- **What is the significance of estimated risk? [Risk Evaluation]**
- What should be done? [Risk Management]

Social Aspects of Risk Acceptability

Valuntary vs. invaluntary: The fact that voluntary risks (e.g. cigarette smoking) are more tended to be taken than involuntary risks (building a new chemical plant). In landslide case, natural and engineered slopes can be considered as voluntary and involuntary, respectively.

Controllability vs. uncontrollability: Onces the risk is under personal control (e.g. driving a car) is more acceptable than the risk controlled by other parties (e.g. travelling as a passenger). The same analogy applies to the perspective of a geotechnical engineer in designing and building a highway slope will have different level of acceptability than public travelling in the highway.

Familiarity vs. unfamiliarity: When people are familiar with risk involved in an activity they are more willing to accept it. Societies experiencing frequent landslides may have different level of landslide risk acceptance that that experiencing rare landslide situations.

Social Aspects of Risk Acceptability

Short vs. long-term consequences: Many people continue smoking, being aware of the fact that they will not affected immediately. Similarly, people leaving on a slope which has very small movement rate may accept the landslide risk unless the movement accelerated by a triggering event.

Presence of existing alternatives: If there are no alternative, many risk can be tolerated by the people. As an example, poorer people, who can not move to a safer place by using their own resources, leaving in a possible landslide area can be more tolerable than richer, who could have more resources to avoid the risk.

Type and nature of consequences: Risks due to events causing more damage and fatality are more difficult to accept (e.g., landslides threatening an urban area vs. landslides in a rural area).

Derived benefits: Derived benefits of society and the individual play significant role in risk acceptance.

Presentation in the media: Verbal and visual presentation of an adverse event in mass media has some influence on risk acceptability

Social Aspects of Risk Acceptability

Personal involvement: If the societies' vulnerable groups such as children, elderly, disabled, etc, are exposed to risk or if a specific person affected by landslide is presented rather than some statistics, the risk acceptance will be affected (Sjoberg and Drottz, 1994). For people having their personnel property in risk there may be different acceptable risk levels than having others' property.

Information availability: Informed societies can have better preparedness for natural hazards, while societies having frequent natural disasters have fresh memories about the consequences

Societal Risk and F - N Curves

Societal risk reflects the society's point of view. In this perspective, risks having low hazard and high consequence are taken into account. For individual and societal risk, the unit of risk is the loss of life/yr. Societal risk is generally expressed by f-N or F-N curves.

When the frequency of events which causes at least N fatalities is plotted against the number N on log log scales, the result is called F-N curves (Bedford, 2004). If the frequency scale is replaced by annual probability, then the resultant curve is called f-N curve.

$$\log f = a + b \log N$$

Properties of F - N Curves

1. **F-N curves are constructed based on historical data in the form of number of landslides and related fatalities.**

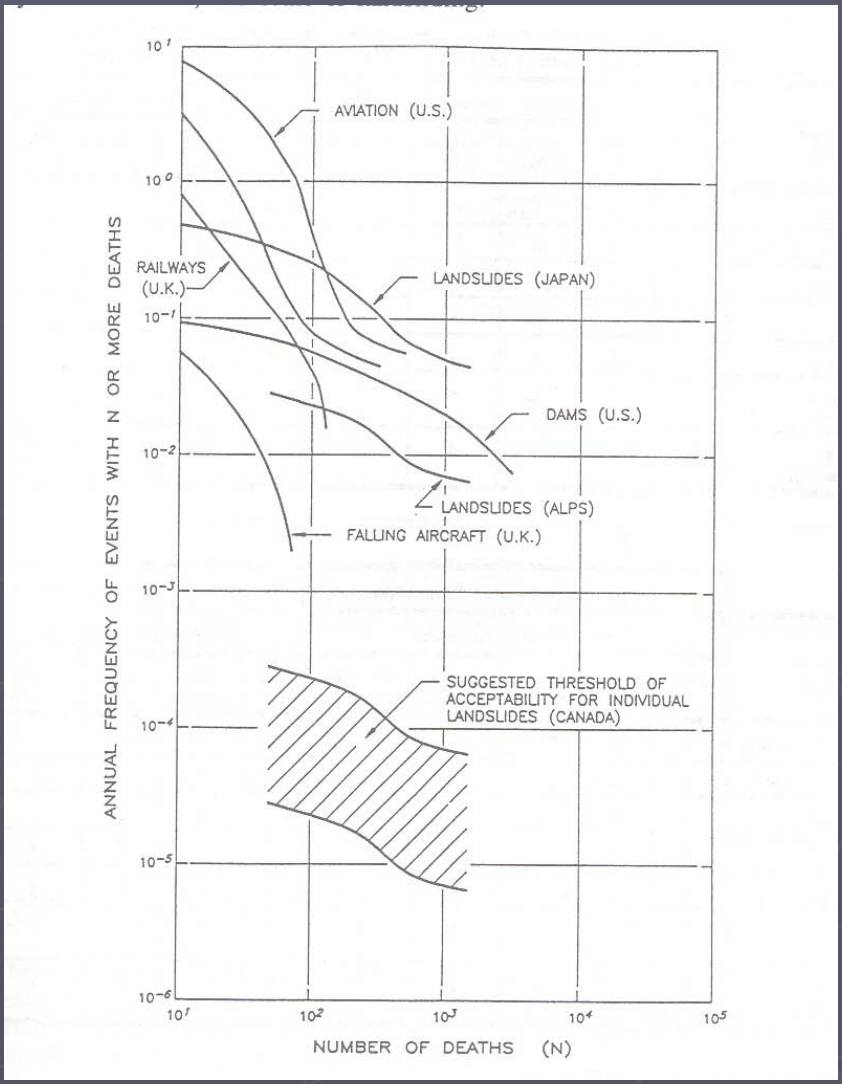
2. **They in fact represent current situation i.e. the situation we live now.**

3. **F-N curves form the basis of developing societal acceptability and tolerability levels.**

4. **The F-N curves can be constructed for various geographical units such as country, province, state etc.**

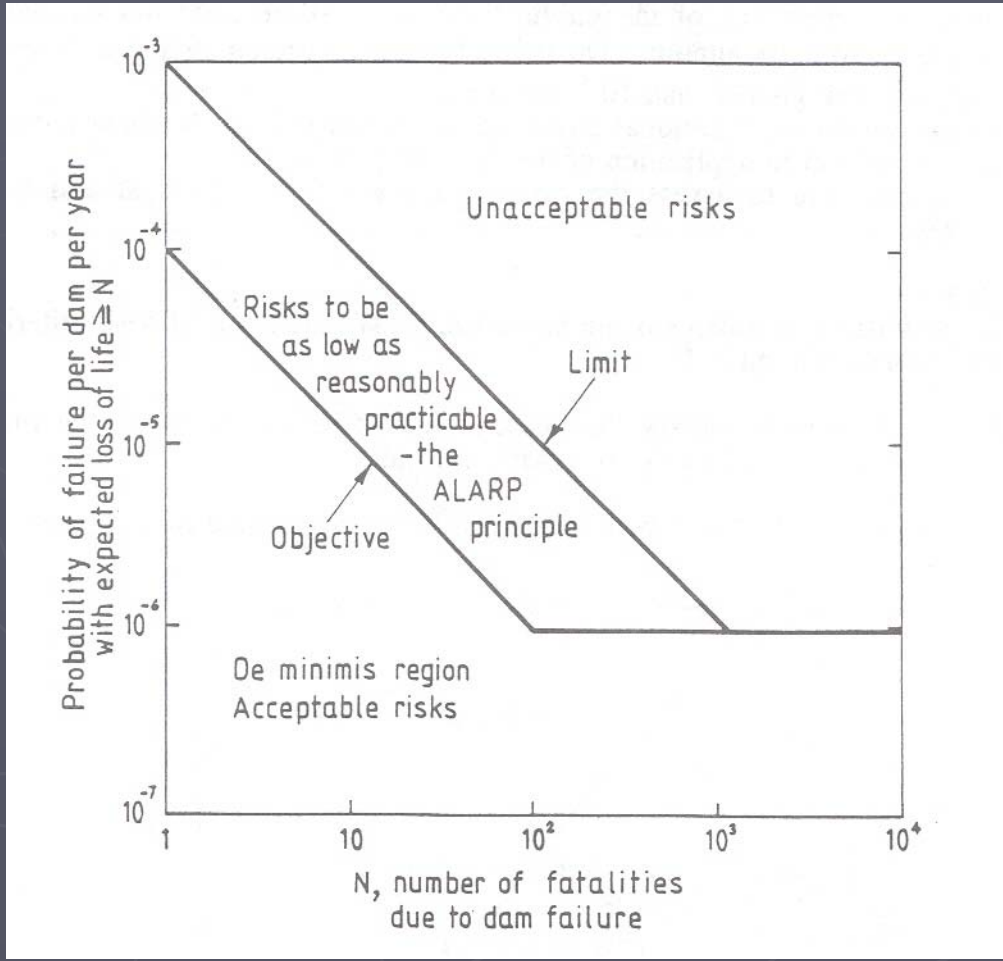
5. **The number of landslides and related fatalities within the considered geographical unit determine the acceptability and tolerability criteria.**

Properties of F - N Curves



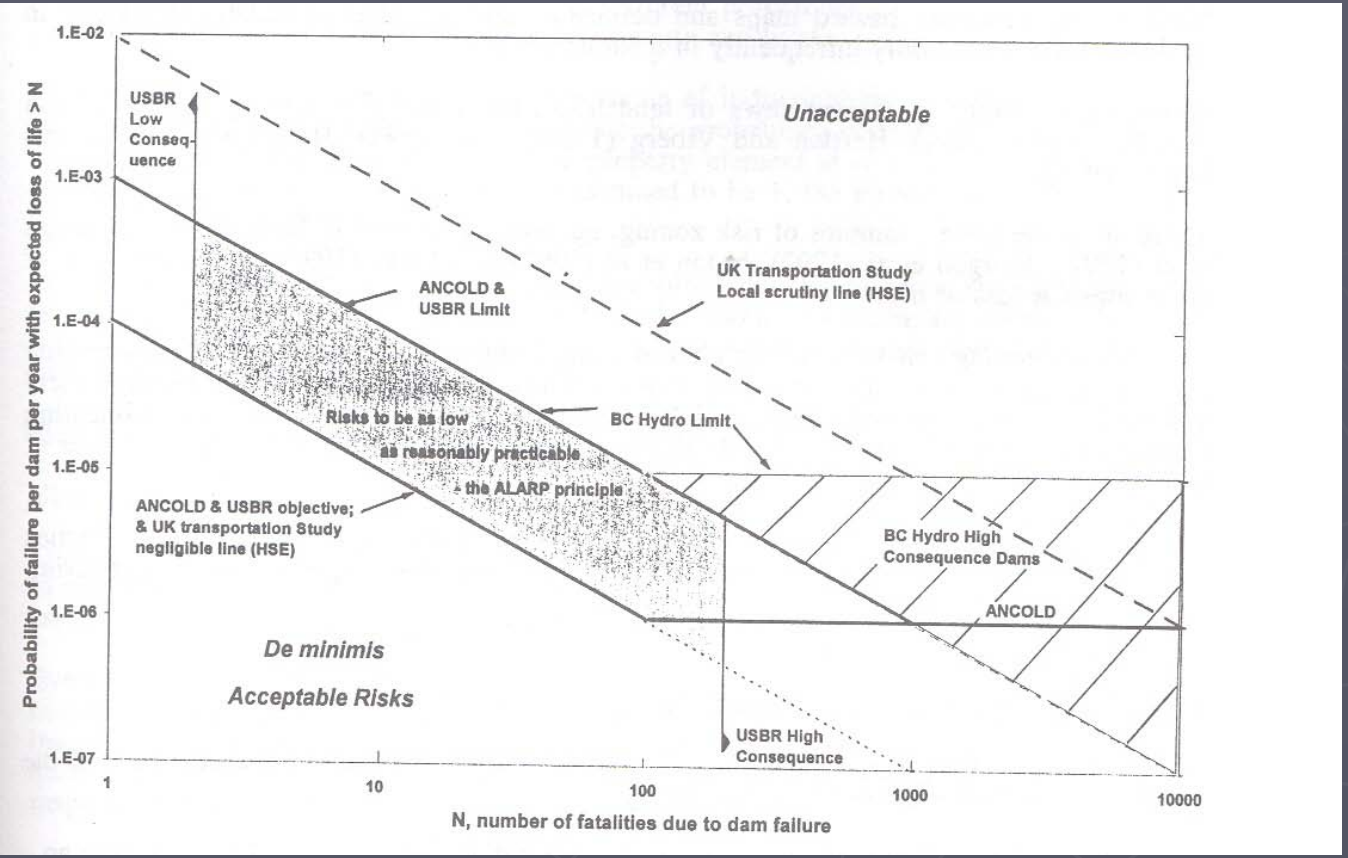
f-N Curve for various natutal and man-made disasters (Morgan, 1991)

Properties of F - N Curves



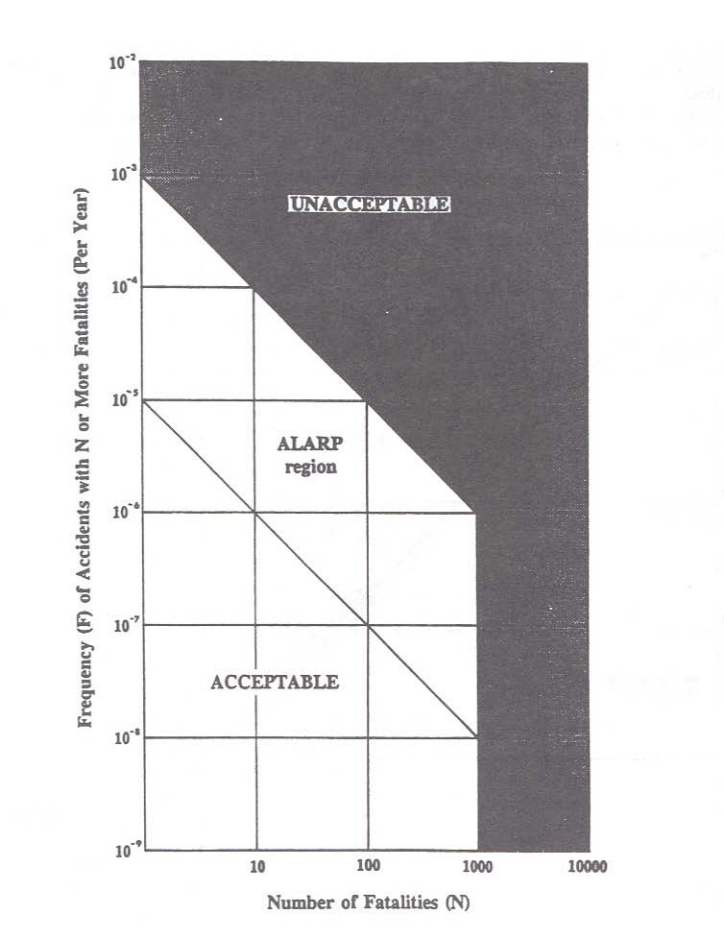
ANCOLD Societal risk criteria (ANCOLD, 1997)

Properties of F - N Curves



Societal risk criteria for dam failures in different organizations (Fell and Hartford, 1997)

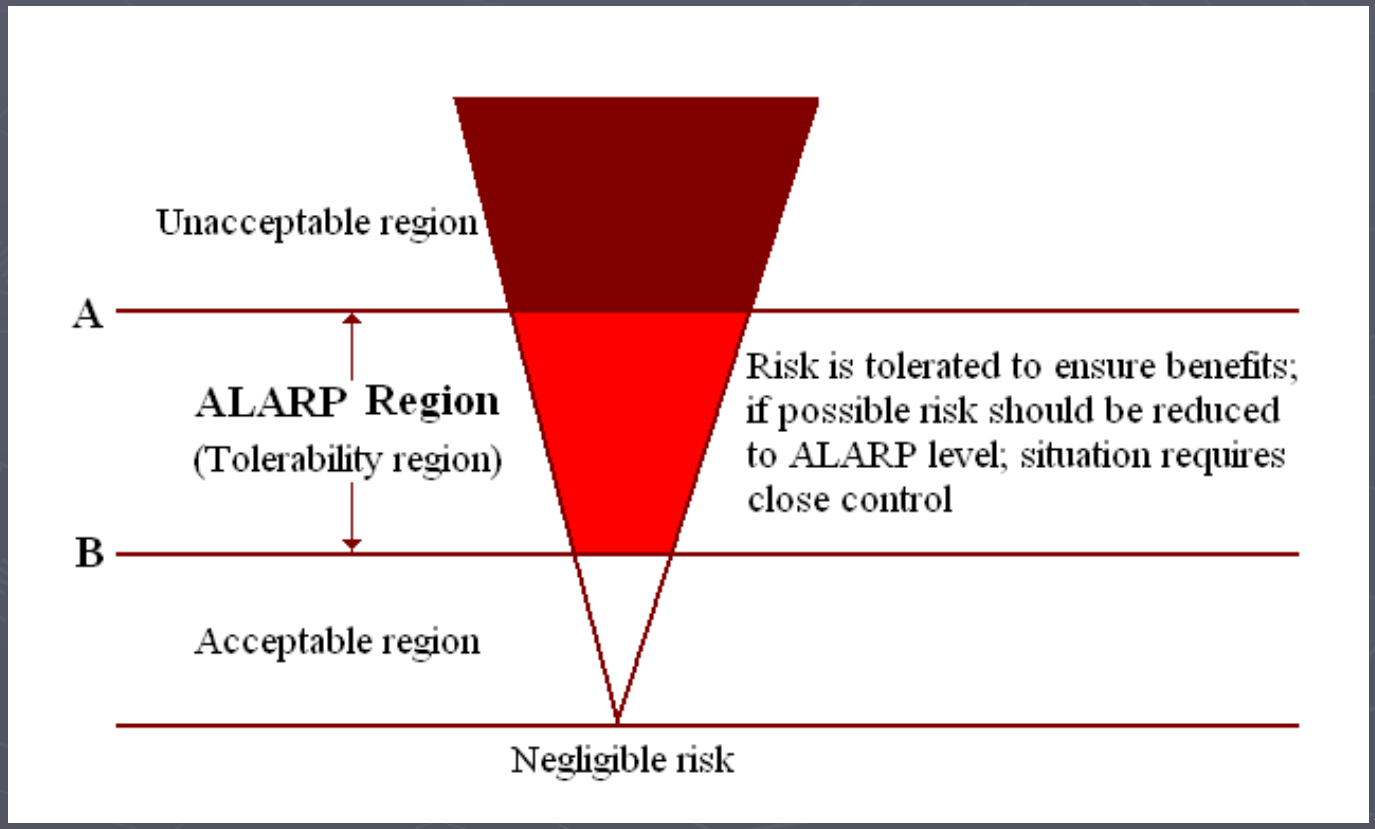
Properties of F - N Curves



Hong Kong Government Planning Department's Societal Risk Criteria for potentially hazardous installations (1994)

Principles of Acceptable\Toletable Risk Establishment

Acceptable risk refers to the level of risk which requires no further reduction. Tolerable risk refers to the risk level assessment in exchange for certain benefits. It is the society's decision whether to accept or tolerate the risk.



General Guidelines for Tolerable Risk Criteria Establishment

(IUGS Working Group on Landslides, Committee on Risk Assessment 1997)

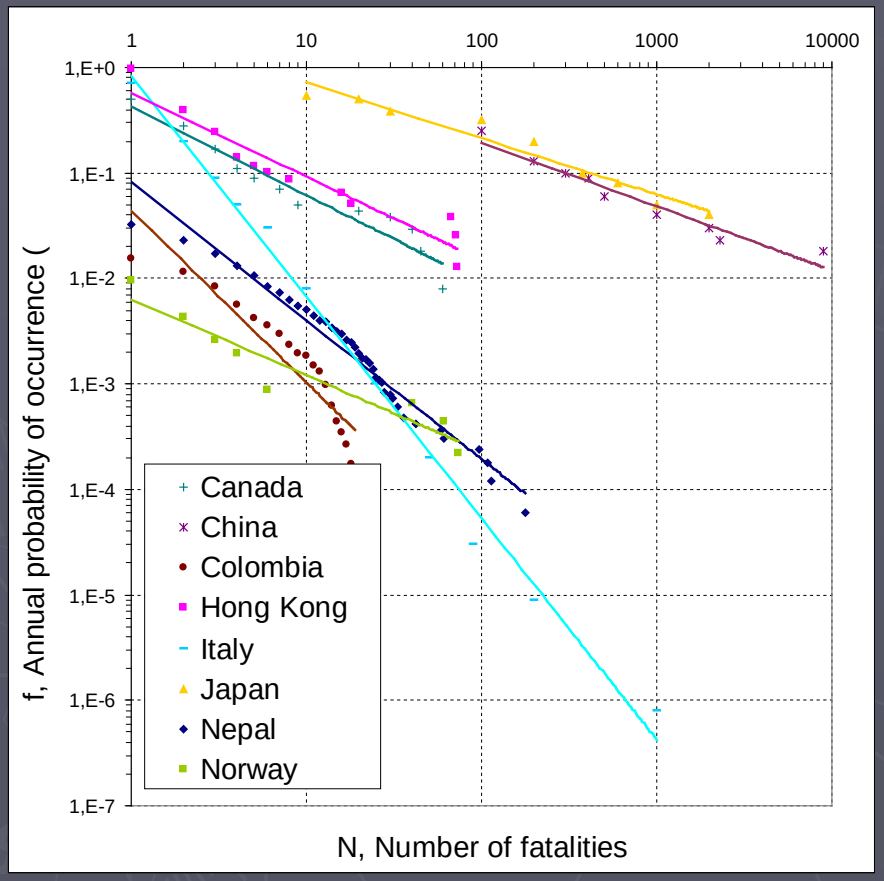
- Incrimental risk from a hazard to an individual should not be greater than the one which is exposed to in everyday life of a person
- The incrimental risk from a hazard should be reduced whereever reasonably practicable (ALARP Principle)
- If the possible life loss is high, the risk should be low
- Individuals tolerate higher risks than they regard as acceptable, when they are unable to control or reduce the risk due to financial or other limitations.
- Higher risks are likely to be tolerated for existing slopes than for planned projects
- Tolerable risks are higher for natural slopes than engineered ones.
- If the slope is under monitoring or risk mitigation measures are implemented, tolerable risk approaches to enginnered slopes.
- Tolerable risks depends on country's experience with landslides.

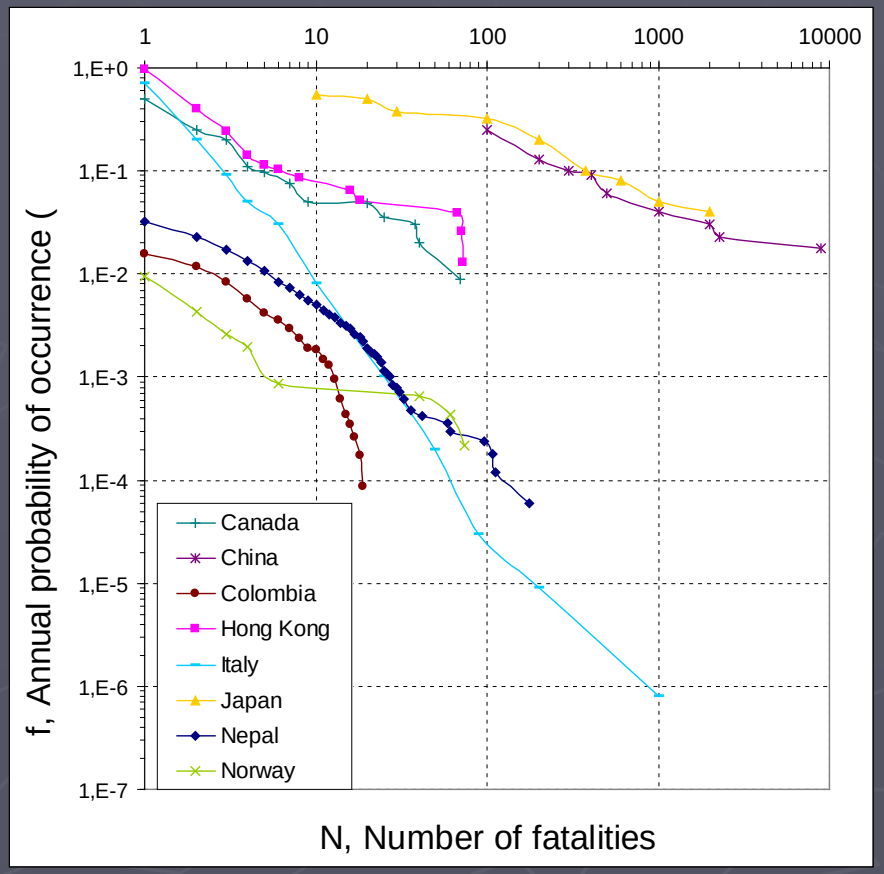
Acceptable Risk Levels for Landslides

Suggested individual risk levels for landslides

Slopes	Individual risk (loss of life/yr)	Reference
Natural slopes	10^{-3}	Fell & Hartford (1997)
Existing engineered slopes	10^{-4} – 10^{-6}	
New engineered slopes	10^{-5} – 10^{-6}	AGS (2000)
Existing	10^{-4}	ERM-Hong Kong (1998)
New	10^{-5}	

F-N Curves for Landslides in Different Countries



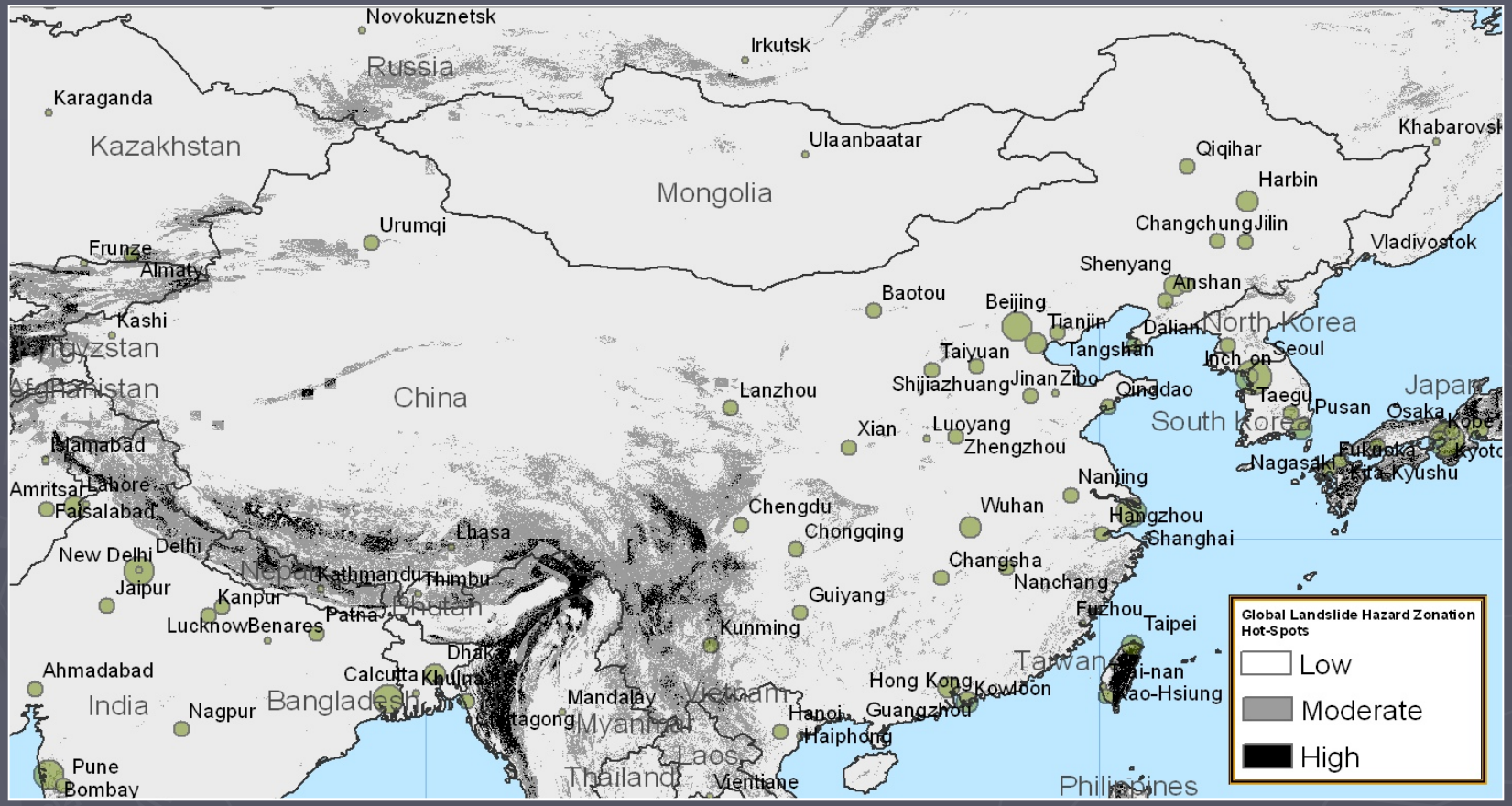


F-N Curves for Landslides in Different Countries

Population density and f-values for eight countries.

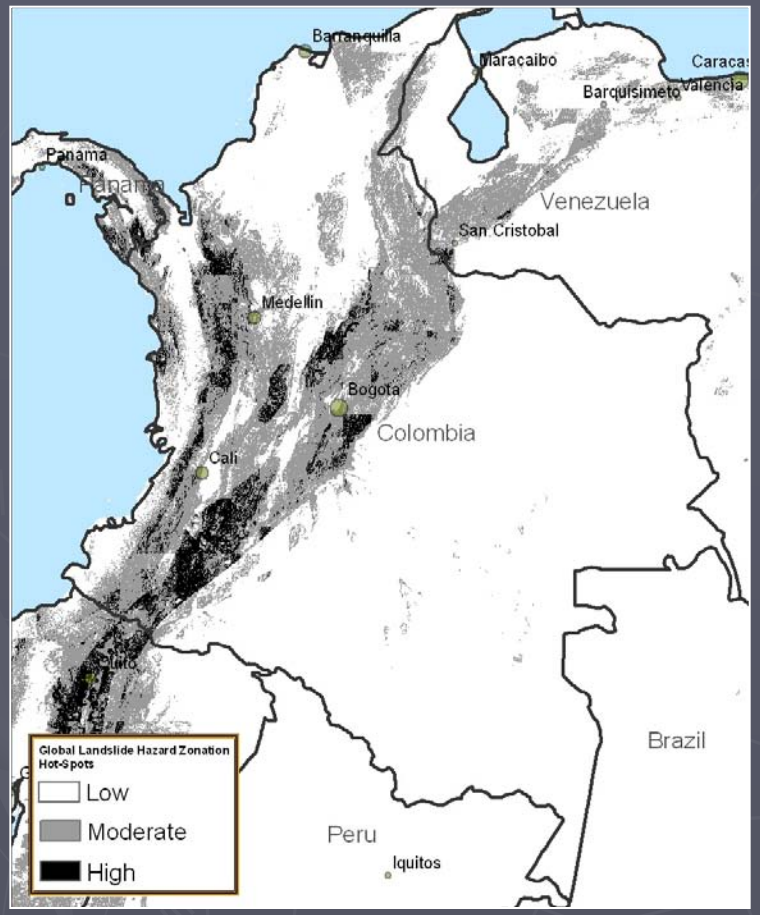
Country	Population density / km^2	f-values			Slope (b)
		N=1	N=10	N=100	
Japan	336	1	0.8	0.07	-0.53
China	136	1	1	0.06	-0.61
Italy	193	0.9	0.008	$5x10^{-5}$	-1.99
Hong Kong	6437	0.6	0.01	-	-0.79
Canada	3	0.4	0.07	-	-0.92
Colombia	37	0.04	0.001	-	-1.63
Nepal	173	0.08	0.004	-	-1.31
Norway	14	0.006	0.001	-	-0.72

F-N Curves for Landslides in Different Countries



Landslide hazard map of China

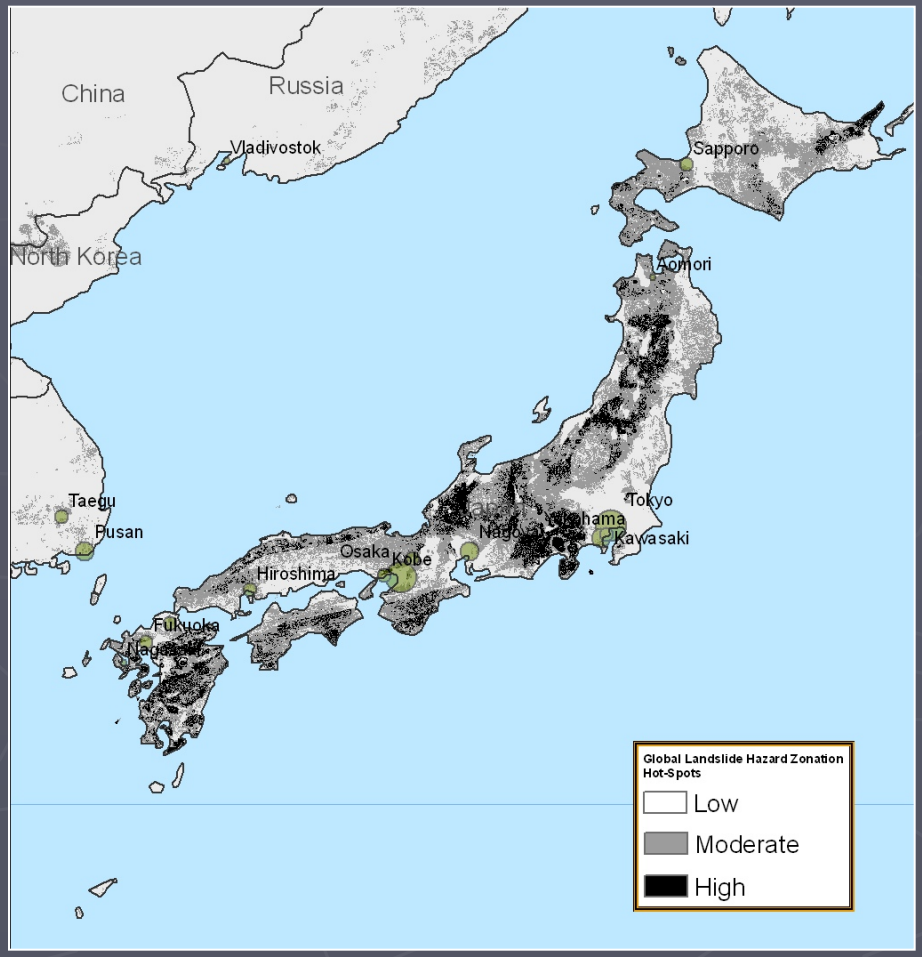
F-N Curves for Landslides in Different Countries



Landslide hazard map of Colombia

Landslide hazard map of Italy

F-N Curves for Landslides in Different Countries



Landslide hazard map of Japan

Conclusions

- **Acceptability/tolerability requires risk perception research in different countries and societies.**
- **It is also equally important to develop acceptability and tolerability criteria for environmental risks due to landslides.**
- **As a consequence, establishing risk acceptability for landslides requires interdisciplinary research.**

THANKS

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