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How to measure uncertainties in environmental risk assessment

R.M. Darbra, E. Eljarrat, D. Barceló

John A. Paravantis

Decision makers of ecological policy and management require sound scientific information on the environmental risk associated with many different activities

Environmental risk assessment should be communicated to decision makers and regulators in a common, sound language

Estimating risk involves

(1) Identifying the events (that present hazards and produce risk)

(2) Communicating the magnitude of the consequences associated with these events

(3) Estimating the likelihood of a given risk

For a complete environmental risk assessment, a great amount of data is required

Environmental data is

- Qualitative
- Vague
- Imprecise

especially in the case of

- newly emerging contaminants

Incomplete information is notoriously common in environmental issues

Imprecision of environmental data

+

Randomness of events

+

Role that human judgment plays (in determining the risk and communicating its significance)

=

Uncertainty associated with risk assessment

Research is under way to explore techniques that can incorporate uncertainty and imprecision into the assessment process

Stochastic and fuzzy-set techniques have been commonly used to accommodate uncertainties associated with risk-modeling inputs and outputs

- Stochastic techniques
  - Scientific reasoning model
  - Based on
    - Probability theory
- Fuzzy-set techniques
  - Human reasoning model
  - Based on
    - Linguistic parameters
    - Qualitative assessment

Risk = combination of hazard and vulnerability

Hazard = probability that a potentially detrimental event of given characteristics occurs in a given area, for a time period

Vulnerability = degree of intrinsic weakness

Risk can be measured by pairing

- Probability of occurrence of an event
- Outcomes or consequences associated with that occurrence

Risk assessment = the process of estimating the possibility that a particular event may occur under a given set of circumstances
Risk management = the process whereby decisions are made about whether an assessed risk needs to be managed, and the means for accomplishing that management

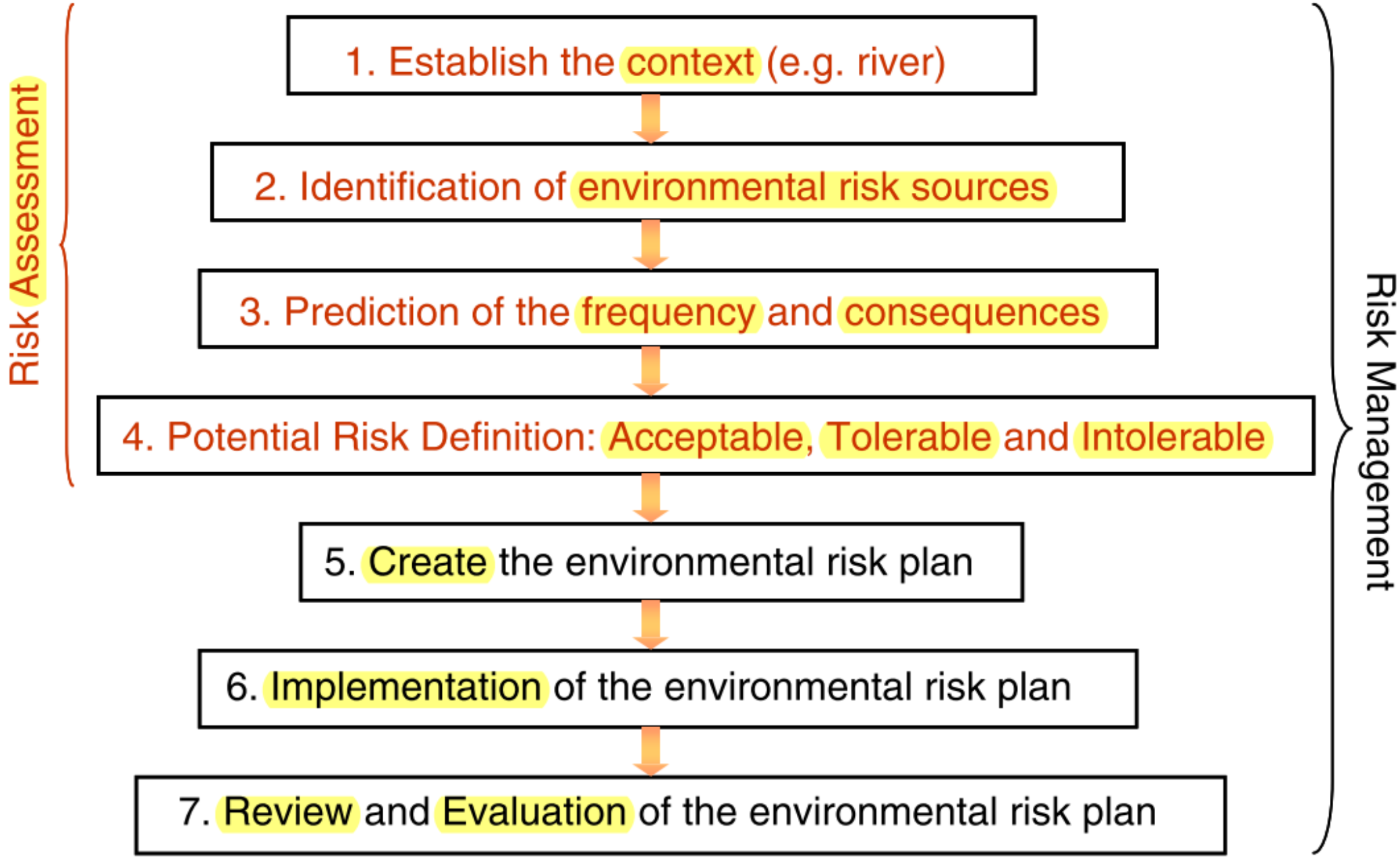

Figure 1. Steps in environmental risk management.

Risk assessment = the most important step in the risk-management process

- Provides a scientific, sound basis for making decisions

Risk management = making decisions based on the information collected in risk assessment

The final decision of how to manage risk is generally human in nature

Apart from the results gathered in risk assessment

(a) Social and cultural values

(b) Economic realities

(c) Political factors

are borne in mind

Insight about risks is limited by

- Randomness inherent in nature
- Lack of sufficient information about
  - Chances of a risk occurring
  - Potential consequences of such an occurrence

So, uncertainty is inherent in risk assessment

- Uncertainty in the measurements of hazard and vulnerability is often large

There is large consensus in the scientific community about the usefulness of risk assessment

- Appropriate tool for attaining a reasonable compromise between
  - A sound scientific approach
  - The need for simple, transparent and pragmatic decision-making instruments

Uncertainty = lack of knowledge regarding the true value of a parameter

Two sources of uncertainty affecting parameters in risk assessments

(1) Randomness (due to variability of phenomena, or because all factors affecting the system being studied cannot be modeled)

(2) Incompleteness (when there is simply a lack of information regarding parameter values)

When information is incomplete or statistical data are not available, human experts can supply information on parameter values

It is possible to classify the uncertainties associated with risk in two broad categories:

(1) Stochastic (due to the randomness)

(2) Cognitive (due to the vagueness of expert judgments)

There are two techniques to accommodate these kinds of uncertainty:

(1) Probability theory (for stochastic uncertainties)

(2) Possibilistic theory (i.e. fuzzy logic) for cognitive uncertainties

The probabilistic approach is used when sufficient information is available for estimating the probability distributions of uncertain parameters

The fuzzy-set method is well suited to dealing with uncertainties when little information is known

- E.g. imprecise knowledge associated with human-language descriptions