Risk-based definition of priority areas for soil protection

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Need

- A method is required for assessing the risk of unacceptable anthropogenic harm to soils as a basis for identifying priority areas for risk reduction (soil protection action).

HAZARDS (**P**ressures)
-Land management (tier 1)
-Land utilization (tier 2)

NATURAL LAND CHARACTERISTICS
-Climate
-Slope
-Landscape position

THREATS
-Organic matter decline
-Erosion
-Compaction
-Salinisation
-Loss of soil biodiversity

SOIL (Receptor)

HARM TO SOIL SYSTEM (**S**tate change)
-Hydraulic properties
-Nutrient processing
-Carbon transformation
-Physical structure

IMPACT ON SERVICE CAPACITY
-Food, fibre and bio-fuel production
-Carbon sequestration
-Water management
-Biodiversity support

Risk
A combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence

Illustrative risk estimates and thresholds

- Water erosion
  - Probability of exceeding a rate of loss of soil by water erosion greater than 3 t ha^{-1} y^{-1}; the threshold could be a probability of 90%, 60%, 50%, etc

- Soil organic matter decline
  - Probability of exceeding a rate of decline of soil organic carbon content greater than 5 % of concentration (w/w) y^{-1}; the threshold could be a probability of 90%, 60%, 50%, etc

Key steps

- Identify a quantitative measure of harm for each threat
- Map soil types (receptors) to define ‘soil polygons’
- Map land management (hazards)
- Estimate probability of exceeding levels of harm, for each soil polygon
- Apply at Tier 1 (broadly equivalent to continental scale) and then in areas of higher risk at Tier 2 with more soil type and land management / utilization categories
- Produce maps of estimated risk of harm from threats by mapping soil polygons
- Define thresholds for acceptable harm
- Map areas of acceptable and unacceptable risk

Illustrative measures of harm

Threat	**Measure of harm**	**Units for risk estimation**
Erosion (water and wind)	Loss of soil mass per unit area	t ha^{-1} y^{-1}
Decline in soil organic matter	Change in concentration (w/w) of soil organic carbon For peats and organic soils: change in carbon stocks	(g/ kg) y^{-1} t ha^{-1} y^{-1}
Compaction	Change in packing density	Mg. m^{-3} y^{-1}

Input data: soil types

- There is a variety of soil types and their response to threats is different
- It is proposed that a map of WRB soil type polygons at an appropriate scale (ideally, at least 1:250,000) should be the first step in delineation of priority areas

Soil data as a 1km raster

Input data: land management hazards and land characteristics

- Land management is the main source of hazards to soil. At tier 1 this may be represented by land use
- The threat intensity depends on interaction of the hazard with natural land characteristics such as climate and slope.
- Thus there is a complex spatial interaction between soil type, land and land management which determines the probability of harm to soil. Therefore data is required on land characteristics

Quantitative risk estimation

- For each threat and each soil polygon, estimate the probability that a level of the corresponding measure of harm will be exceeded.
- Requires a predictive model of rates of change in measures of harm, using spatial soil and land management data sets.

Risk evaluation

- How much risk of harm is acceptable?

- Some options:
  - How resilient is the soil? Rates of harm should not exceed rates of recovery.
  - What are the impacts of different levels of harm on capacities to provide ecosystem services and goods?
  - Cost-benefit analysis

Delineation of risk-based priority areas

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Soil polygons with estimates of the risk of harm to soil from different threats within them.

Allocate polygons to an acceptable or unacceptable risk categories

Produce maps, one for each threat, showing areas of acceptable and unacceptable risk of harm to soil.

For example: Estimate the probability of exceeding an annual rate of loss of topsoil organic carbon of 2 percent per year. The risk estimates for each polygon can then be described as not acceptable or acceptable, if it is decided that an acceptable probability of not exceeding 2 percent per year is 80%.