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Agroscope

Characterisation of Soil Quality: Which challenges?

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Assessment

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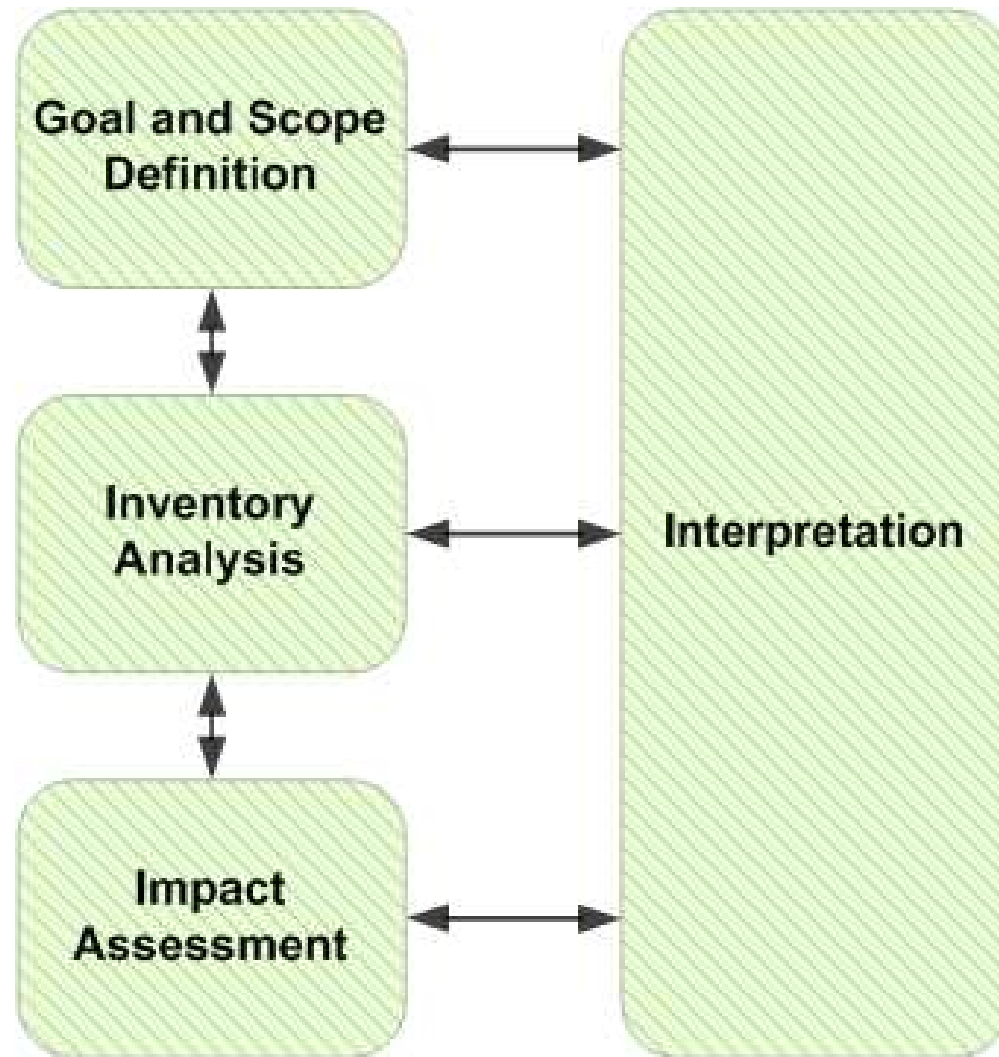
Overview

- LCA basics
- Midpoint versus endpoint indicators
- Soil quality basics
- How to characterise
- Grouping as alternative
- Conclusions



LCA basics (1)

How to
organize
this
transition ?





LCA basics (2): Some definitions

- *A life cycle inventory (LCI) includes information on all of the environmental inputs and outputs associated with a product or service i.e. material and energy requirements, as well as emissions and wastes*
- *However, a long list of substances is difficult to interpret that's why a further step is needed known as life cycle impact assessment (LCIA). An LCIA consists of compulsory and optional steps:*
 - **Classification: all substances are sorted into classes according to the effect they have on the environment.**
 - **Characterization: all the substances are multiplied by a factor which reflects their relative contribution to the environmental impact.**
 - *Normalization: the quantified impact is compared to a certain reference value, for example the average environmental impact of a European citizen in one year.*
 - *Grouping: Sorting and ranking*
 - *Weighting: different value choices are given to impact categories to generate a single score.*

Source: Pré Website (adapted)



LCA basics (2)

- What is the LCI in the context of soil quality?
- What is the LCIA category «soil quality»?
 - Is there a category «soil quality» in LCA?
 - Or are there several categories which contribute to «soil quality»?
- What is the general context of characterisation?
 - Midpoint or endpoint approach?
 - «Soil quality» is a category interesting for itself, to be fully defined
 - «Soil quality» is a transition issue between LCI and endpoint categories which depend on other issues than those related to soil quality, like biodiversity, water quality, climate

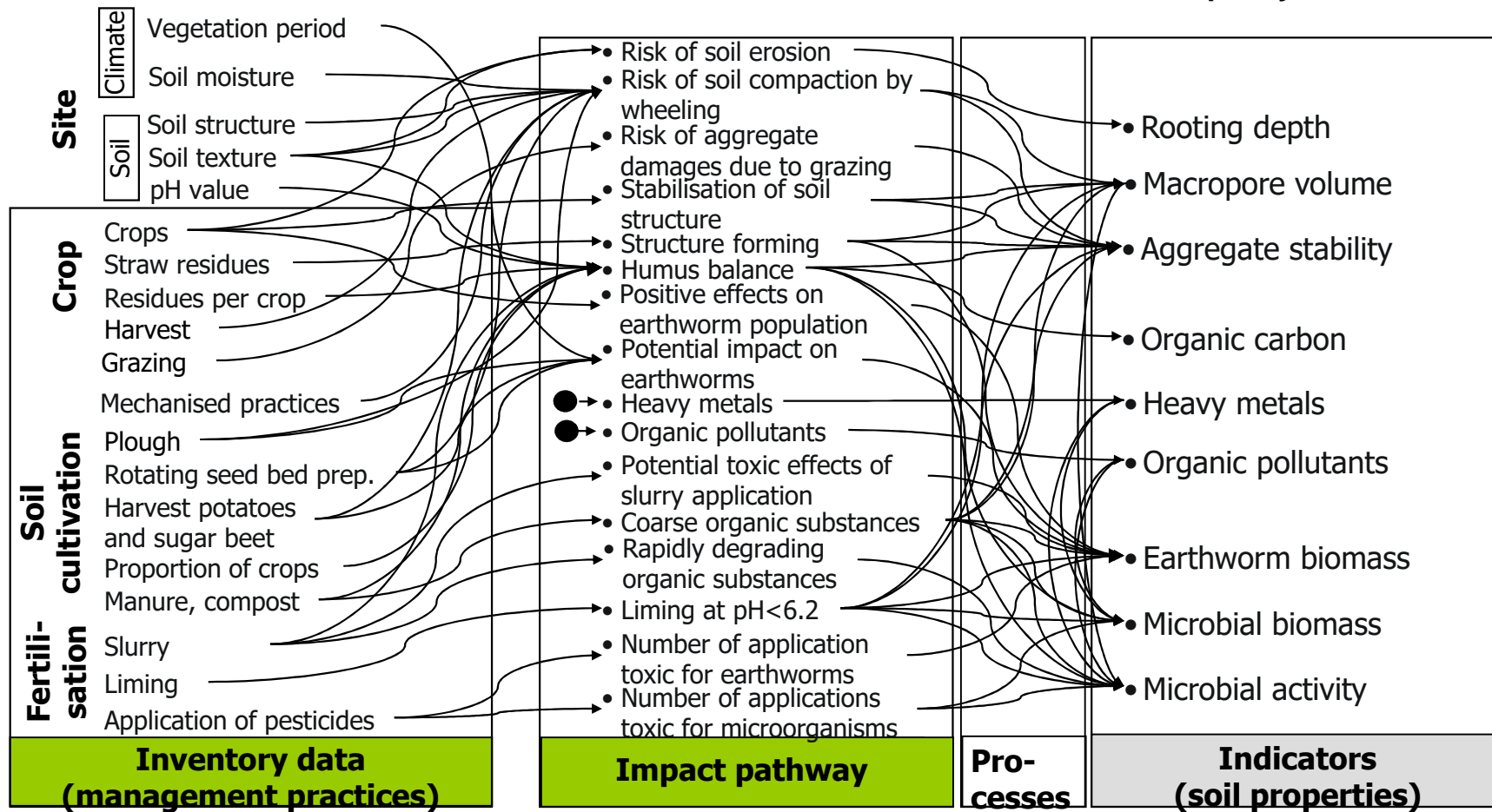


Example for a mid-point approach (SALCA, Oberholzer, 2012)

Life cycle inventory data (management options)

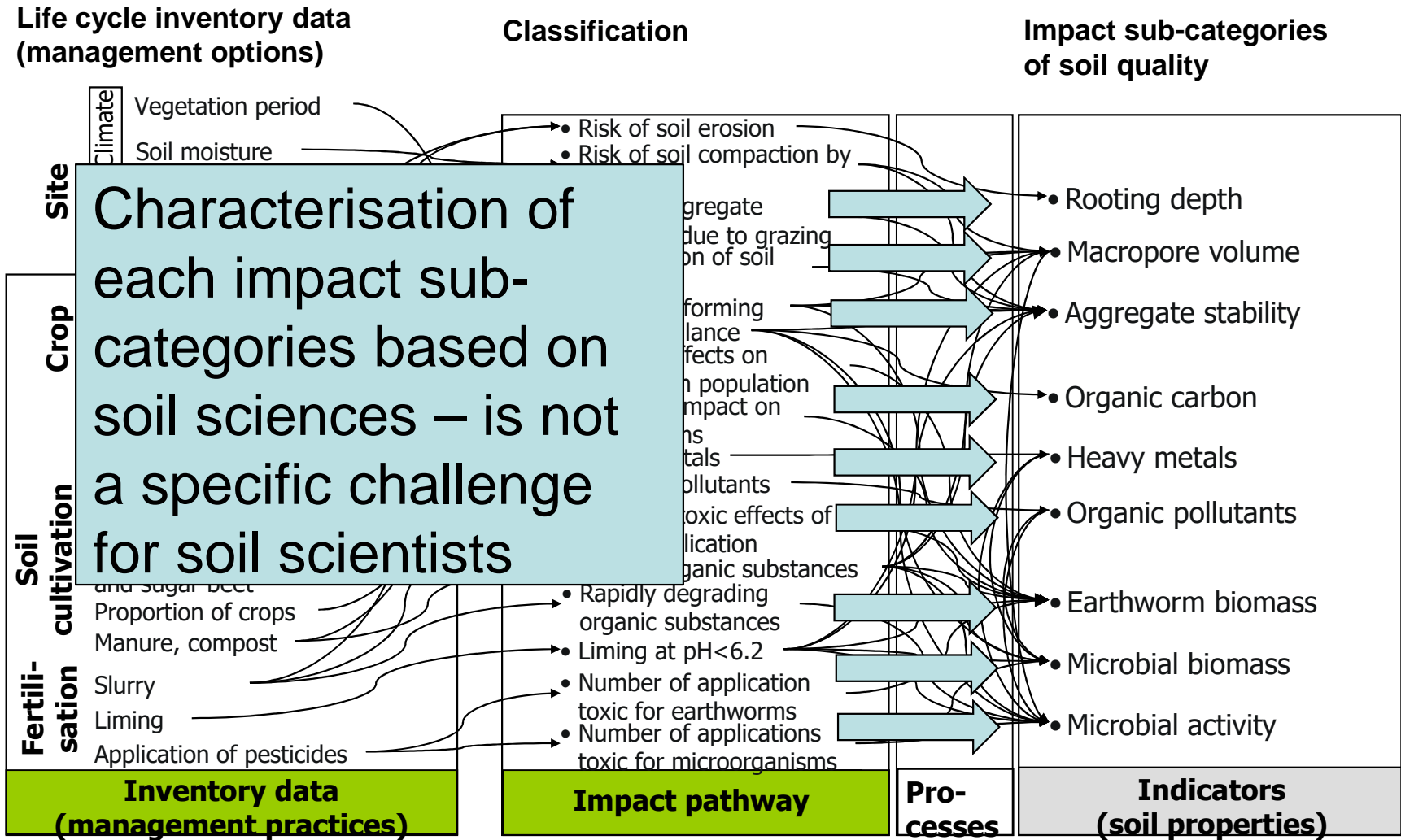
Classification

Impact sub-categories of soil quality



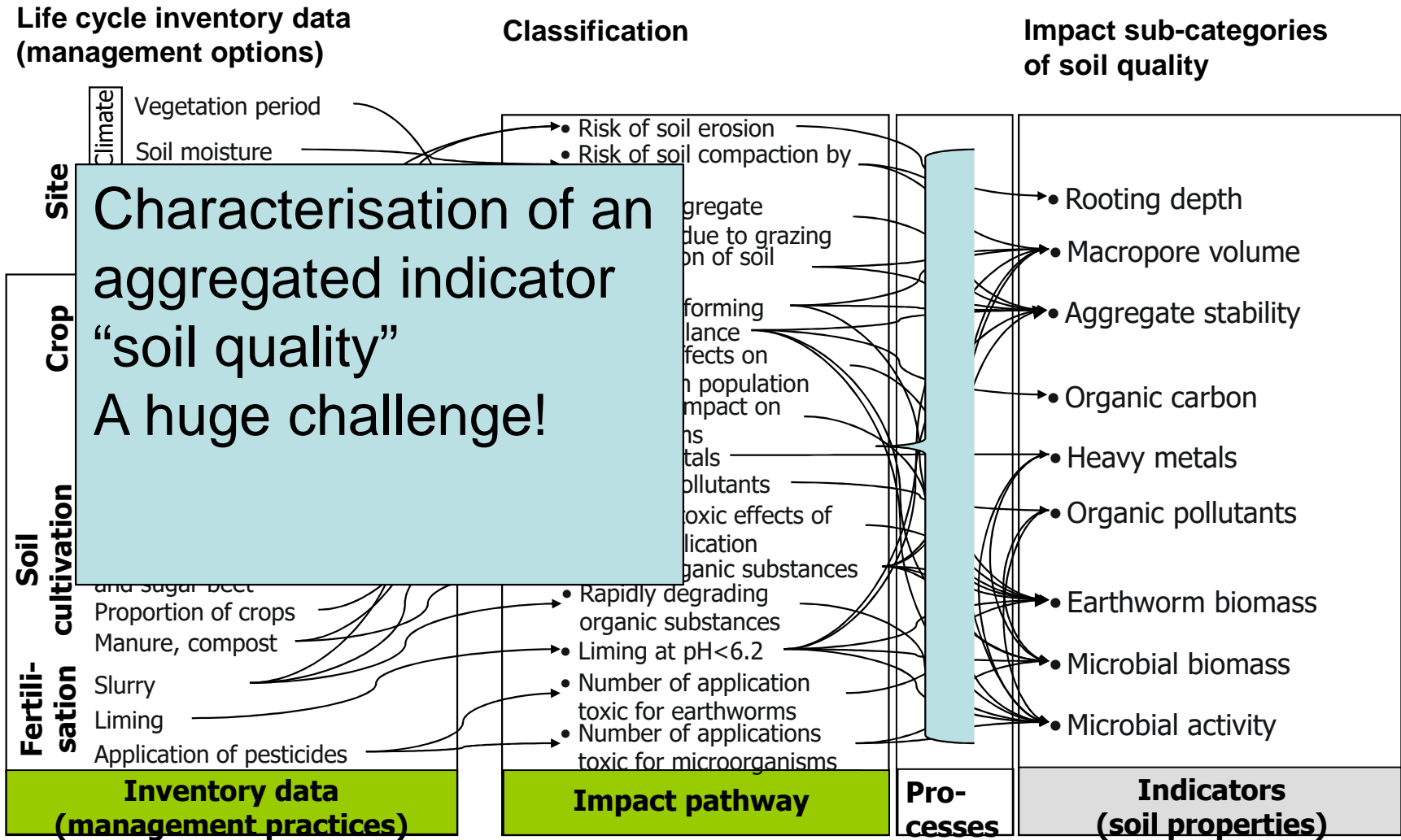


Example for a mid-point approach (SALCA, Oberholzer, 2012)





Example for a mid-point approach (SALCA, Oberholzer, 2012)

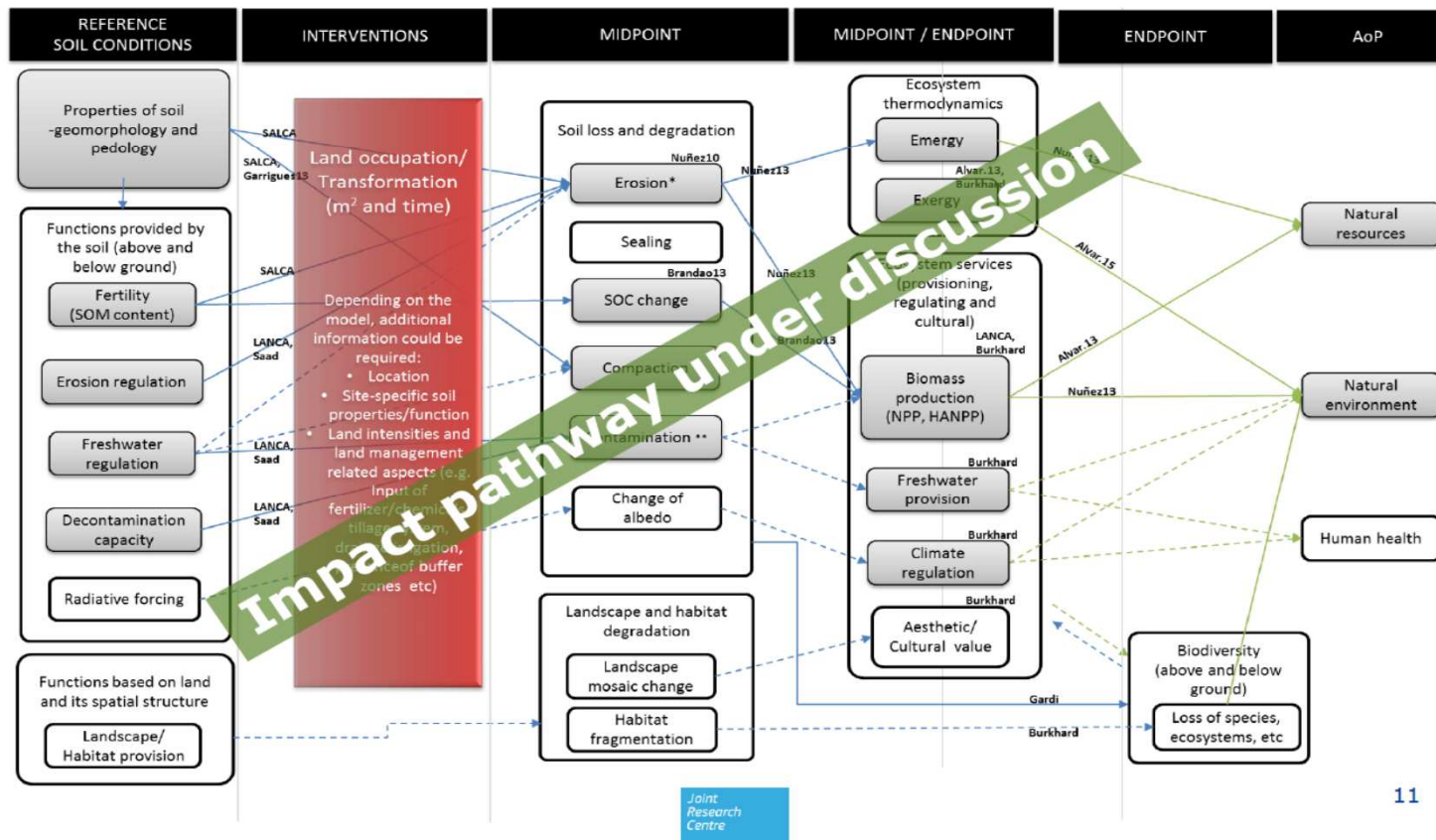




Example of an endpoint context (JRC, Sala, 2015)

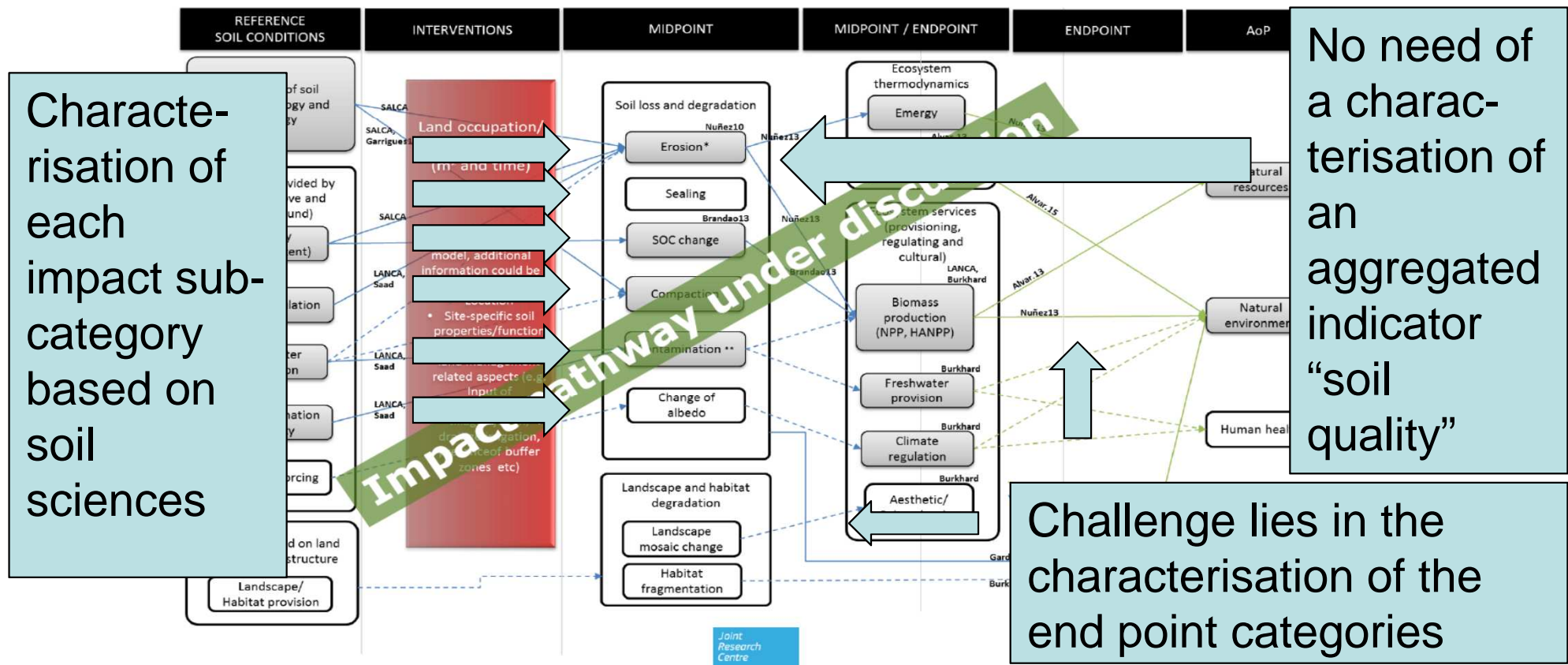


Impact pathways





Example of an endpoint context (JRC, Sala, 2015)





Aggregated indicator?

- Prerequisite for a characterisation is that an impact category does exist
- Does soil quality exist as impact category in the sense of an LCA?
- => What is an impact category?
 - ISO: «Class representing issues of concern to which LCI results may be assigned»
 - This implies to perform the classification step up to the impact category and not to stop at the stage of the subcategories
- => What is soil quality?



What is soil quality?

Oberholzer et al. (2012)

*In modern soil quality concepts soil quality is defined based on the **interaction of soil functions and soil properties in an ecological context** (Benedetti et al. 2000, Schjønning et al. 2004). Karlen et al. (1997) defined soil quality as “... the **capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation**”.*

*This definition means rather the ecological soil quality in the sense of Milà i Canals et al. (2006). Soil quality as such can not be measured directly and thus it can only be inferred from an array of measured indicator values (Nortcliff 2002). **Several different indicators have been proposed, each covering certain aspects of soil quality** (Doran and Parkin, 1996, Harris et al. 1996, Karlen et al. 1998, Nielsen and Winding 2002, Breure et al. 2003, Oberholzer and Höper 2007).*



What is soil quality?

Garrigues et al. (2012)

Soil quality is the **capacity of a specific kind of soil to function**, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation” ([Karlen et al., 1997](#)).

The most important functions include **water flow and retention, solute transport and retention, physical stability and support, retention and cycling of nutrients, buffering and filtering of potentially toxic materials, and maintenance of biodiversity and habitat** ([Andrews et al., 2004](#)). A soil may have a high quality for one function but not for other functions. In contrast, the latter definition of soil quality can be simply defined as “fitness for use” ([Larson and Pierce, 1994](#) and [Letey et al., 2003](#)). Thus, the **soil-“function” definition** emphasizes soil ecological services, whereas the **soil-“use” definition** implies specifying soil uses according to a soil's environmental or industrial context (e.g., agriculture, road construction). The latter definition also implies responsibilities for those who use soil. These two definitions are interrelated and have been integrated, for example, in a sequential framework that evaluates a soil's quality for a specific purpose while considering its functions ([Carter, 2002](#)). Thus, while **soil quality can be considered the degree to which soil can meet a set of functions and/or uses**, the members of the set may vary according to the soil context, the issues considered important, or the method used to analyze soil quality.



What is soil quality (3)

- Degree to which a soil can meet the set of meaningful **ecological functions** ?
- Degree to which a soil can meet the set of meaningful **anthropogenic uses** ?

- **Both ??**
- **The same word for two different ideas, consequently two different methods?**

- **Unit: Percentage (degree of fulfilment)**

How to characterise (1) ?

- How to measure the degree to which a soil can meet the set of meaningful **ecological functions** ?
- Requires to
 - Definitive list of the ecological functions
 - Classification between the subcategories and the functions
 - Criteria according to which a function is more or less relevant considering the goal and scope definition of the LCA
 - Criteria according to which a function is seen as being fully fulfilled (reference)
 - Criteria according to which a partial fulfilment may be defined
 - Criteria according to which a hierarchy between different functions (e.g. in order to cope with trade-offs) can be set
- For example
 - Species resp. habitat loss resp. richness resp. function (LCI Biodiversity task force, Anton, 2015)
 - Water purification (Saad et al, 2013), groundwater regeneration (Bos et al., 2016)
 - => Create a link with LCIA midpoint methods for biodiversity, water, climate for consistency reasons



How to characterise (2) ?

- How to measure the degree to which a soil can meet the set of meaningful **anthropogenic uses** ?
- Requires to
 - Define the meaningful uses
 - Biomass production vs. other uses like habitat, transport or natural reserves
 - Biomass production for food vs. feed, fibre and fuel
 - Classification between the subcategories and the uses
 - Criteria according to which a use is more or less relevant considering the goal and scope definition of the LCA
 - Criteria according to which a use is seen as being fully fulfilled (reference)
 - Criteria according to which a partial fulfilment may be defined
 - Criteria according to which a hierarchy between different uses (e.g. in order to cope with trade-offs) can be set
- For example (Garrigues et al., 2012)
 - Cost to rehabilitate soil or prevent soil degradation
 - Reduction of net primary production



Alternative: Grouping

Grouping

- *“is another optional step, although it is seldom applied in LCA studies” (Curran, 2015)*
- consists of **sorting** and possibly **ranking** the impact categories
 - sorting on a nominal basis (like soil relevant categories)
 - Ranking on an ordinal basis (like soil erosion before soil microbial activity)

In other words

All types of actions which are not based on natural or environmental sciences, but which try to structure the interpretation of the mid-point indicators results on the basis of the Goal and Scope phase



Conclusion

- Define the context
 - Characterisation of a category soil quality is mainly a challenge for a midpoint approach
 - Up to my knowledge, no midpoint method to soil quality performs the classification step until the targeted impact category «soil quality» - however, this should be a prerequisite for any characterisation step
 - Two main definitions / perceptions of soil quality
 - Ecological functions vs. anthropogenic uses
 - Proposal: Characterisation unit defined as a degree of fulfilment
 - Different criteria exist in the literature for both definition types
 - Alternatives
 - For the midpoint approach: Structured use of the LCA grouping procedure
 - Or focus on endpoint characterisation frameworks